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# Canadian Aeronautical Journal

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CONTENTS


| | | |
|---|---|---|
| EDITORIAL: THE PRESIDENT'S MESSAGE | *T. E. Stephenson* | 179 |
| SUMMARY OF THE 12TH ANNUAL NATIONAL FORUM OF THE AMERICAN HELICOPTER SOCIETY | *W. H. D. Hanchet* | 180 |
| THE R.C.A.F. – TECHNOLOGY ON ACTIVE SERVICE | *A/V/M M. M. Hendrick* | 181 |
| FIELD DATA ANALYSIS | *B. Larmour and S/L J. E. Neelin* | 187 |
| THE COMET 4 – DESIGN AND OPERATIONAL CONSIDERATIONS | *R. E. Bishop and G/C J. Cunningham* | 197 |
| C.A.I. LOG<br>Secretary's Letter, Annual General Meeting, McCurdy Award, Annual Reports, Branches, Members, Sustaining Members. | | 207 |


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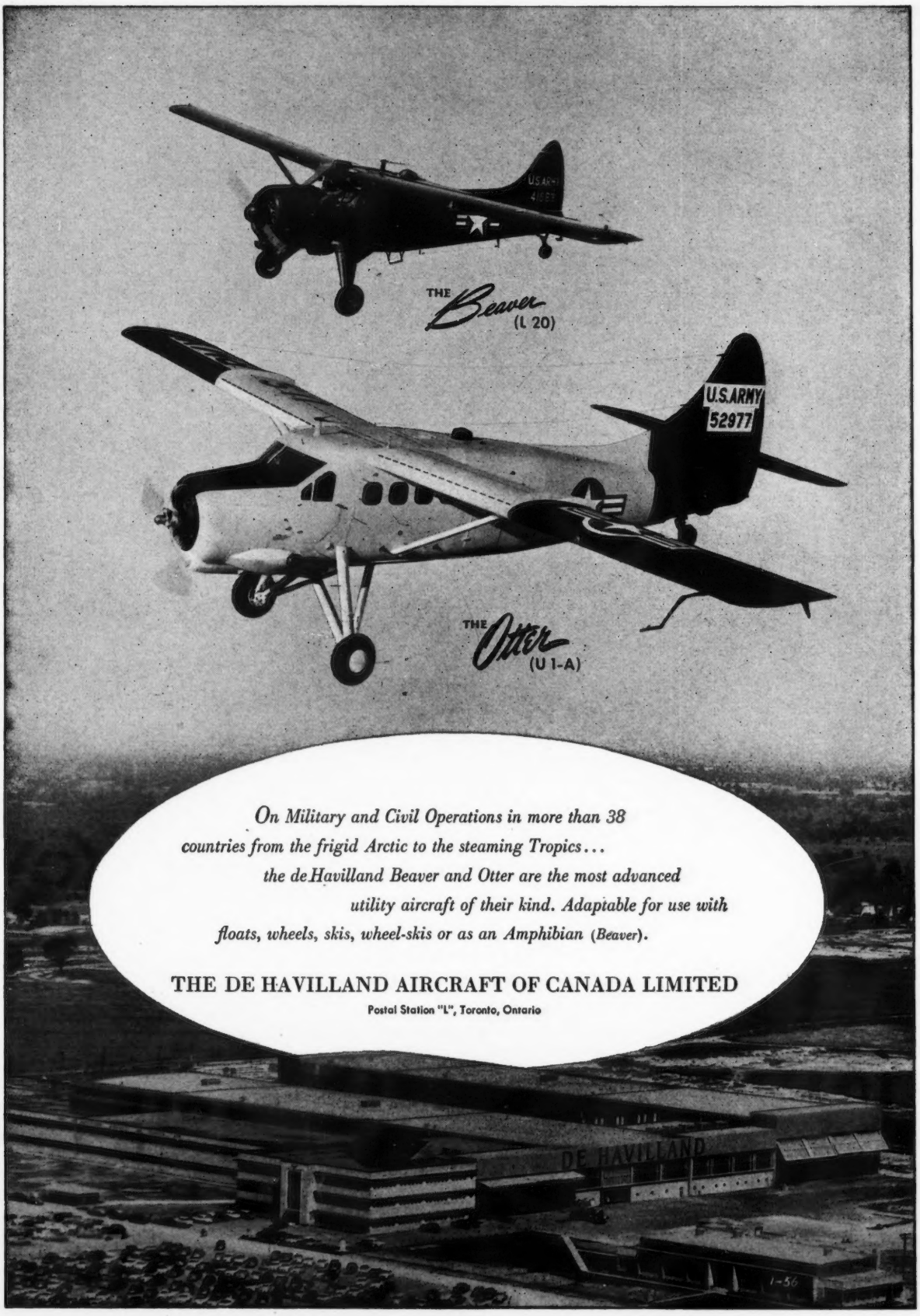


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JARRY HYDRAULICS announces that complete facilities for full qualification testing of hydraulic units and landing gear are now available at their Montreal laboratory. This equipment ensures the accurate testing of newly-designed parts to MIL Spec. requirements. The laboratory will provide invaluable information to Jarry Hydraulics and other companies wishing to take advantage of it, and represents another step forward in the development of Canada's aircraft industry.

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1 Structural Test Bed, 10'-0" wide x 22'-0" long, capable of absorbing Bending Moments of 10,000,000 lbs. ins. Used for tests on major landing gear and hydraulic components.

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1 Test Bed 13'-0" long, fitted with Hi-Lo Temperature chamber used for development and qualification testing of units under simulated aircraft loading conditions with automatic temperature programming in the range from − 100° F to + 300° F. Chamber can take units up to 7'-6" retracted length and is 2'-0" square inside.

2 Test Beds 10'-0" long, fitted with Hi-Lo Temperature Chamber and Automatic Temperature Control, over the range − 100° F to + 300° F. Used for units up to 4'-6" retracted length. Chamber is 2'-0" square inside.

1 Sand and Dust Rig, for testing of units up to 8'-0" long. Working section is 2'-0" square x 8'-0". Sand velocity is variable over a wide range, the density being controlled automatically.

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Electronic measuring equipment includes: oscillographs, oscilloscopes, strain indicators, pressure and acceleration transcribes etc.

*Designers and manufacturers of Landing Gear and other Hydraulic Components for modern aircraft. Jarry produces for the —*

| | | |
|---|---|---|
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Jarry Hydraulics

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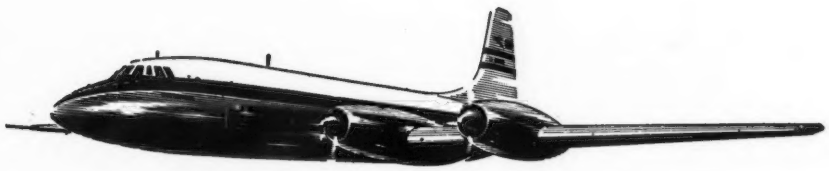

# Britannia

The Bristol Britannia is a long range airliner powered by four Bristol Proteus free turbine turboprop engines. With its maximum payload of 28,000 lb the still air range of the Britannia 310 is 4,940 statute miles, and with 16,000 lb it is 6,220 miles. Its cruising speed is in the 350-415 mph range. This aircraft is developed from the Britannia 100, now being produced for British Overseas Airways Corporation, but is fitted with the more powerful Proteus 755 engines giving 4,120 equivalent brake horsepower. The Britannia 250 general purpose cargo/passenger version can carry more than 80 passengers and several tons of freight over ranges similar to those covered by the Britannia 310.

This performance makes non-stop all-the-year-round operation across the Atlantic possible on a scheduled airline basis. Moreover, the economic flexibility of the Britannia is such as to allow stage distances of as little as 600 miles, so giving an airline a single vehicle capable of operating commercially over the most varied route pattern.

***A total of 40 Britannias is on order for airline use. Five of these are for the Canadian Pacific Airlines; nine more are being supplied to the British Services for trooping and strategic transport duties and a maritime reconnaissance version of the aircraft is being built by Canadair Limited of Montreal.***

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It comes as no surprise that many of tomorrow's big and fast-flying aircraft are selecting the brake which gives up to 50% increase in absorption of kinetic energy per pound of brake. And so it is with the new Douglas DC-7C, Lockheed's Model 1649A and several new military planes on which model numbers have not been released.

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The simplicity of design of the Goodyear Tri-Metallic Brake gives a spectacular reduction in number of parts — over 200 parts less than in other brakes of comparable capacity. This means greatly reduced inventory and maintenance man-hours.

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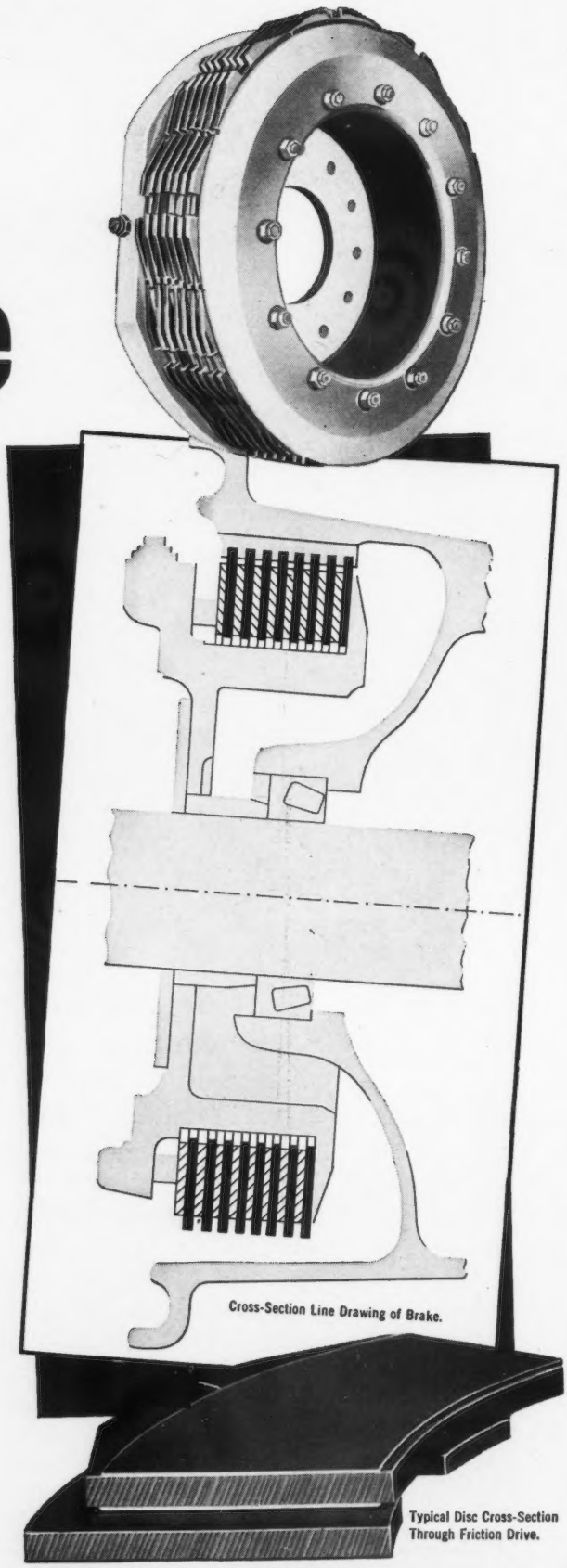

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*Over 550 skilled pilots fly TCA's fleet. Some have 2 and 3 million flying miles to their credit.*

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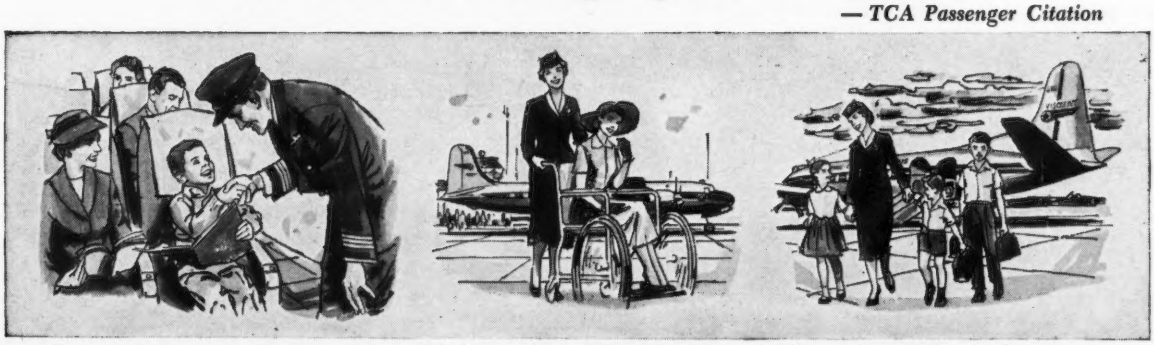

"Another kindness was shown me by the steward who served my 5-year-old son's meal early in order that I might enjoy more quietly my own meal. My son also got his wish to meet the pilot."

*— Passenger Citation*
(Toronto to Vancouver)

"My daughter uses a folding wheel chair and when we came down at Bermuda the stewardess suggested taking Janet out in her chair for some sunshine. We know that this is very unusual service."

*— (U.S.) Passenger Citation*
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"One is always a bit worried when three children travel alone for any distance. It is difficult to express the assured feeling it gave me to see the attention given these three children by TCA staff."

*— Passenger Citation*
(Toronto to New York City)

**It's the friendly, personal quality of TCA service — ground and aloft — that's so frequently singled out for praise by travellers from other lands. As a U.S. visitor wrote recently: *"Your personnel seems dedicated to making TCA one of the better airlines."***

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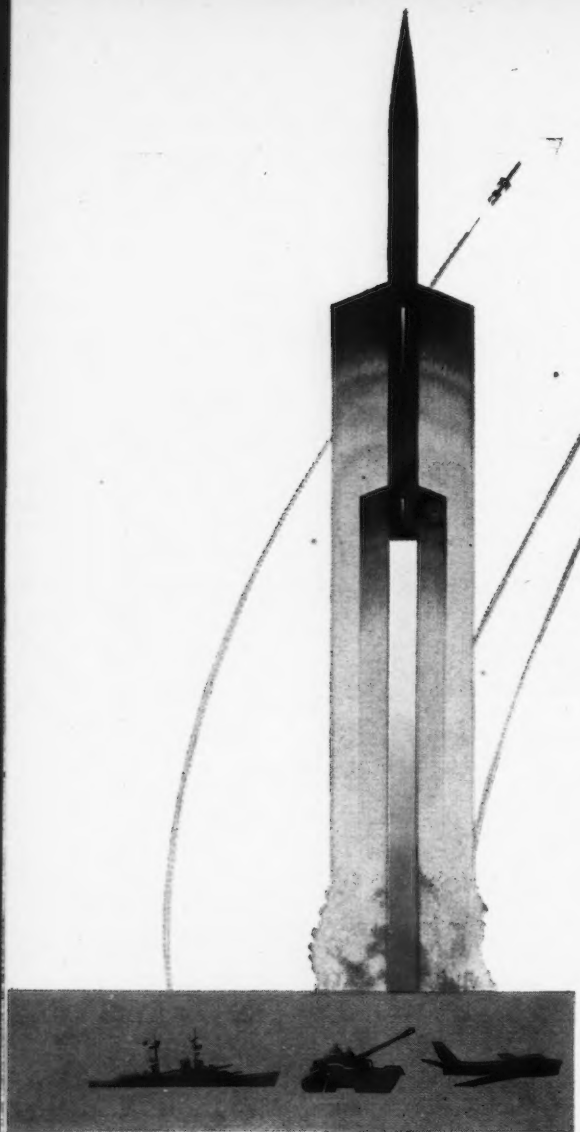

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The development of guided missiles of every type is becoming one of the most competitive areas in our world today . . . for supremacy in this field can well determine peace for many years. The race is now for greater speed, higher altitude, longer range, more sensitive control.

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## THE PRESIDENT 1956-57

T. E. Stephenson

# EDITORIAL

## THE PRESIDENT'S MESSAGE

THE position of President of the Canadian Aeronautical Institute is a great challenge, for it devolves upon your new Executive to maintain the growth and vigour of our Institute. To do this effectively, we will need the full support of all the membership and we hope for and expect this support from all those who are called upon to administer the Institute's affairs.

The Canadian Aeronautical Institute exists primarily to foster communication amongst the technical personnel in the aviation industry in this country. It does this through the Journal, the Branch Meetings and the National Meetings. The Journal has been a very great success and the Institute owes a great debt to those devoted people who have worked so hard on it. The criticism most often heard of the Journal is that its appeal is too restrictive, that is, certain grades of membership are not catered to. Your Publications Committee is aware of these comments and takes account of them within the limitations imposed by the available papers. The true remedy lies with the membership itself, for members in specialist groups should submit papers on their subjects. There is no surplus of good papers. Branch meetings are well attended, and cover a wide field in the larger centres. The newer, smaller Branches have a serious problem in obtaining speakers, for they do not have the personnel from which to draw speakers. Your Executive is endeavouring to assist these Branches by arranging, in so far as possible, for out-of-town speakers. The National Meetings have been unqualified successes. We are very appreciative of the tremendous help given us in this regard by the Institute of the Aeronautical Sciences. Their help and participation have been the primary reasons for the success that we have achieved.

Your Executive will do everything in its power to improve our service to the membership in all these areas of communication.

In the coming year we want to improve our service to the specialist groups. The aerodynamicists have led the way here and we feel their example can be followed with profit. Each National Meeting session is, of course, aimed at special interests and development of this approach, together with administrative assistance from our Headquarters, should enable us to make it unnecessary for the specialist groups to feel the need for separate organizations. We now have an organization which truly represents the range of aeronautical skills and we must seek to maintain this unity.

As you are all aware, during the past year we had an active group studying the education and training of technical personnel, with a view to recommending to Council concrete steps that might be taken to assist in this field. I am happy to say that the Committee has done excellent work and that results will be forthcoming this year. This is one of the ways in which the Institute can repay industry for its generous financial support.

Your Executive looks forward to a useful and active year and is confident that, with the support of our able Secretary, Charles Luttman, we can turn over a flourishing society to the next Executive.

T. E. STEPHENSON,
*President 1956-57*

# SUMMARY OF THE 12TH ANNUAL NATIONAL FORUM OF THE AMERICAN HELICOPTER SOCIETY

## May 2nd to May 5th, 1956

by W. H. D. Hanchet

*Doman-Fleet Helicopters Ltd.*

### Engines

DESCRIPTIVE papers on two new lightweight gas turbines were given by Lycoming on the T-53 and by General Electric on the T-58. This is believed to be the first time that information on these two machines has been made public. The following performance figures were revealed:

| | Weight | Normal Power | Military Power | S.F.C. (Normal) | S.F.C. (Military) |
|---|---|---|---|---|---|
| T-53 | 460 | 770 | 825 | .71 | .71 |
| T-58 | 325 | 875 | 1024 | .69 | .66 |

The above figures are approximate.

### XV-3 convertiplane

Another descriptive paper covered the development of the XV-3 convertiplane and a movie showed some of the first flights of this aircraft. The author concluded that large convertiplanes of the same basic type as the XV-3 could be built in the light of existing knowledge and that such a large convertiplane would fill the gap between pure helicopters and fixed-wing aircraft.

### Helicopter design

A paper on helicopter design and test requirements made the following interesting recommendations:

(1) The desired maneuvreability of the helicopter define the aerodynamic design of the rotor.

(2) The aerodynamic capabilities of the rotor define the structural design load factor and structural flight tests of the helicopter.

(3) Adequate consideration be given to fatigue requirements with due regard to the inadequacy of the present state of the art to predict oscillatory component loads with any reasonable degree of accuracy.

These recommendations are based upon actual experience and are contrary to current practice.

### Instrument flight

No less than four papers were devoted to problems associated with instrument flight or navigation in helicopters. One of these, based upon U.S. Navy experience, was devoted largely to a description of automatic stabilization. Another described the experience of N.A.C.A. in making instrument approaches in a single rotor helicopter at various approach angles and over a wide speed range and another described the requirements of non-scheduled commercial helicopter operators. In general, all these pointed up the need for more research and development in instrument flight. A final paper on this general subject presented these recommendations based upon the experience of New York Airways:

(1) Helicopter and fixed-wing aircraft should be assigned different altitudes and tracks to allow more efficient use of terminal air space.

(2) Control criteria should be changed to allow more positive "on time" compliance by helicopters and fixed-wing in the terminal areas.

(3) Recognition of the fact that at the present state of the art helicopters can be flown on a very accurate track and altitude visually and fixed-wings in the terminal area fly very accurate tracks on the present nav. aids (ILS, RADAR, VOR, etc.).

### Pilot training

A carefully developed paper on military helicopter pilot training made recommendations to better satisfy present operational pilot requirements and prepare for the broader operations of the near future.

### Subsidy

A paper entitled "Why No More Helicopter Subsidy" presented many examples of subsidies given to various industries in the U.S.A. since the time of George Washington and concluded with this paragraph:

> "In conclusion, having considered the billions of dollars spent by the Federal government to subsidize various segments of the American economy, having considered the past subsidies given to the transportation industry to foster its development in its early infancy, having considered the relatively large subsidy payments made to the local service air carriers, and having considered the responsibility of the Civil Aeronautics Board to continue the development of air transportation, I believe that it is in the interest of public welfare; the interest of national defence; and the interest of consistent national transportation policy that we justly ask the question – Why No More Helicopter Subsidy?"

### Military operations

Several papers on various aspects of military operations were presented. Of these, the one discussing the use of helicopters as tugs was perhaps the most startling. Several original uses were discussed in this paper which predicted that these new fields could just about double the number of helicopters now in service.

### Air show

The Forum closed with an Air Show at one of the military airports near Washington. This was one of the best Air Shows that this writer has had the privilege of seeing. Nearly every type of operational helicopter was represented and an opportunity to examine different machines at close range was provided after flying ceased. One of the most dramatic features was a fly past of a large number of U.S. Army transport helicopters in close formation.

# THE R.C.A.F.—TECHNOLOGY ON ACTIVE SERVICE†

**by A/V/M M. M. Hendrick***

***Royal Canadian Air Force***

**Air Vice-Marshal M. M. Hendrick**

WHEN deciding what to talk about to you tonight, it would be natural that I should wish to talk about the Royal Canadian Air Force. But you, as members of the Canadian Aeronautical Institute are a rather special audience in that you know already a great deal about the Air Force. Most of you have served in or worked with the Air Force in the past or are doing so today in industry, in the government or in the Service itself. So in that sense I am speaking to a very specialized and knowledgeable audience when the subject is the R.C.A.F. of today. Therefore it might be more interesting to talk about the future – but such talk to be specific involves plans, and plans introduce security and this is a public gathering. Thus, I find myself in the dilemma of speaking to a knowledgeable audience but unable to talk about anything which can be considered classified. I certainly don't want to talk in generalities and bore you to death and I certainly don't want to talk in excessive technicalities and bore the ladies to death. Furthermore, you will have had one day already of very erudite and technical discussions and you are in for another one tomorrow, so tonight one must be non-technical, non-secret, non-repetitive, certainly non-political and positively not dealing with policy. On top of this we must be stimulating, witty and, to take up the Governor-General's recent challenge, original, provocative and far-seeing. It must be obvious at this point that we are going to have to request a few waivers on this specification. You know the old Pentagon slogan "The difficult we do immediately, the impossible takes a little longer" – so in this undaunted spirit tonight I will take a little longer and if anyone wishes to doze off, I will take it as a tribute to the dinner and not the speech.

†Dinner Address read at the Annual General Meeting of the C.A.I. on the 3rd May, 1956, in Montreal.

*Air Member for Technical Services.

## THE AIR FORCE TODAY

I hope it will be interesting to you to take a look at the Royal Canadian Air Force today and some of its trends in the last few years and from this to speculate about what might happen to it in the few years ahead.

In the last seven years your Air Force has grown 5 times in size and I suggest this is a fairly reasonable rate of expansion for any institution or business. During this same period our rate of flying has increased 10 times.

During the early part of this expansion period we were occupied chiefly in training, transport and photographic survey.

In the last three years we have become a jet Air Force. Of the total flying done three years ago, less than 1/14 was on jet propelled aircraft. Today over 1/3 of all our flying is on jets and the proportion is increasing steadily. Furthermore, these jets are now all Canadian-built.

### Canadian Jet Aircraft

At home we have the Canadian designed all-weather fighter the CF-100 – The Canuck – powered by the Canadian designed Orenda engine. It is a good aircraft in spite of criticisms which were aimed at it in the past. It is as good an all-weather fighter as there is in service anywhere today, if not slightly better. It is particularly suited to operate over our relatively unpopulated Canadian north country with a much longer range than any competing all-weather fighter and it packs a wallop in its rocket pods that would do credit to a battleship broadside. With our Air Divisions overseas, we have

the American designed but Canadian-built Sabre VI, powered with the Canadian designed and built Orenda engine, an unique combination which makes it outperform all other Marks of Sabre and, until the Americans bring in their supersonic F-100, still the best day fighter in N.A.T.O. in terms of range, speed and ceiling. At home we do advanced flying training on the American designed Canadian-built Silver Star jet trainer powered by a British engine, the Rolls-Royce Nene, which again gives this particular combination a superior range and speed over its American-built cousin.

Canada can be proud of these aircraft which in more or less degree are unique and can claim to be as good as or slightly better than any other aircraft in their class and time-scale. It is certainly a source of great satisfaction to the Royal Canadian Air Force that the Canadian taxpayer, the Canadian industry and the Canadian Government have teamed up to provide for us such outstanding weapons. Of course, I would be quite unfair to the engineering staffs of the R.C.A.F. and to their policy-making senior officers, with neither of whom was I connected at the time, if I did not suggest tonight that they too deserve a full measure of credit for their vision and technical judgment and direction in helping to achieve these results.

**Ground Installations**

At the same time on the ground we have a Canadian fabricated Pinetree Warning Line as it is called but in effect a Canadian-built electronic control net-work to operate our air defence weapons. Most of the electronic equipment in this particular line was built in Canada to American patterns but the technical buildings in which they are housed, the design of the operations rooms and other operational facilities, as well as the design of the living accommodation and amenities on these stations, is again uniquely Canadian.

**Operational and On Active Service**

With these tools in the last three years, the R.C.A.F. has created a fully operational fighting machine – overseas at our Air Division our operational flying has increased five-fold in the last three years and at home our Air Defence Command has increased its operational flying activities four-fold in the last two years. Not only is our force operational in the truest sense but it is well that you be reminded that it is *on operations* – it is really on active service. I think it fair to say that within the R.C.A.F. is the only group of people living in Canada who really are in the Cold War in the sense that it affects every minute of their daily lives. It affects them in the sense that the Headquarters Staffs and the planning staffs at all levels are working at an intensity which has not been equalled since the last war. It is indicated by the incidence of at least our fair share of hyper-tension, ulcers and coronarys. I can assure you that if unfriendly critics wish to accuse the population of Ottawa of stopping work at five o'clock they will find no supporting evidence among the planning and the operational staffs of the Royal Canadian Air Force.

But it is most apparent in the life and activities of the aircrew and ground crew of the Air Defence Command. These lads serve 48 hours at readiness and 48 hours on duty turnabout for 11 days at a stretch. That is to say they are on immediate call for 48 hours, then on normal working routine for 48 hours, then on call again for 48 hours and so on for 11 days, then they have a 3 day break. When they are on call, some of them must be ready within 15 minutes to be in the air, day or night, Saturdays and Sundays included, and I may say not for any overtime pay. This atmosphere of working under pressure and being on active service is being carried out at home, among you all, where the rest of the population is behaving normally, working a 40-hour five day week and more concerned about whether to buy a new car or a new refrigerator than whether an enemy might appear over the horizon in the next half hour. I would suggest to you that one of the most difficult problems the R.C.A.F. has to face today is to keep this attitude of urgency and alertness and ever-continuous readiness prevailing throughout our Service for just as long as there is the threat to be countered. From the looks of things and the predictions of our statesmen, it would appear that this is going to be for a long, long time. We all take the Fire Department for granted until we have fire at our house and then of course we expect it to be there immediately and I suppose it is natural for the R.C.A.F. to be taken for granted by Canadians until there is an international fire. We hope that there won't be one, but at the same time we must keep prepared to handle it. The only difference is that the Fire Department does get some practice every once in a while with a real fire and this keeps up their skills and spirits because they are doing something visibly useful. We hope we will never have a real fire to deal with and therefore we have to exercise all our ingenuity to practice realistically and at the same time not to loose our keenness, not to get careless, to be always ready, perhaps for years and years on end. This is one of the toughest jobs in the whole Cold War.

**Big Business**

This active service machine is reasonably big business too. Today we consume $32M worth of fuel every year for our fighting and our training aircraft. Our technical inventory of aircraft, vehicles and electronic equipment is valued at $967M. Our buildings and plants are valued at $775M. It costs us $126M a year to maintain this technical equipment, aircraft and electronics and to do this we have an inventory of spares and equipment in the pipeline of over $200M which has to be stored, accounted for, protected, overhauled and kept ready. In dollar value, this pipeline inventory is roughly half aircraft parts and engines and half electronic components, which underlines the interesting fact that with this build-up the important position of electronics as an equal partner with the aeroplane and its weapons has become more obvious. So not only have we become a jet Air Force but we are fast becoming an electronic Air Force.

## AN ELECTRONIC AIR FORCE

**Automatic Flight**

Electronic devices are no longer considered by the R.C.A.F. as minor accessories or aids – they have become essential major components, without which combat

flying is no longer possible. This may be illustrated by two interesting trends—towards fully automatic flight and towards full ground control of flight. We are half-way along the road toward fully automatic flight. You remember before the War most flying was done by the seat of the pants and the man's sense of balance and his eyes and his human reaction-time were adequate to carry out any form of flying, be it civil or military. Now, as all you realize I think, flight is almost entirely instrument flight. Transport aircraft, both civil and military, normally fly under instrument flight rules whether the weather is good or bad and the crews of the aircraft look more at their instrument panel than they ever look out of the window. Nevertheless, the vital task of translating the readings of the instruments to the movements of the controls, particularly during manoeuvres, still depends on the human link and the human intelligence. For the future it is obvious that an increasing amount of the routine of translating the instruments' indications into control movements of the aircraft will be done, under all circumstances, by the machine. The pilot will remain, however, as a monitor to exercise judgment or to select alternative courses of action.

**Ground Control of Flight**

At the same time that flight becomes more automatic the aircraft becomes more dependent upon devices and controls on the earth beneath. In the old days, you all remember, you went from A to B by taking off from a grass field, pointing your nose in the general direction and reading from the map until you arrived at where you were supposed to be. The most complicated form of help you might expect would be by circling low to read the name of the town on the railway station, thereby getting a fix. Today, as you know, the airways are well marked by radio beams of various kinds and you have to fly at a precise altitude and along a precise path, as instructed by the ground control, and on this control you depend for your safety from collision. Around the airport, you cannot enter the circuit to land without permission of the tower and the aircrafts' arrivals and departures are spaced and controlled by the organization on the ground. In a complicated airport like Washington or London, the form of control is even more complex. By means of radar all aircraft in the area are continuously watched and guided and instructed exactly what to do in order to stay out of each other's way and to arrive and depart in an orderly manner. A pilot, in other words, is required to remain on a pre-defined track almost as rigidly as if he were a railway train on the iron rails. In the case of landings, the earth control is even more precise, whether it be by ILS or GCA the exact position of the aircraft in space from instant to instant is defined by the earth control and must be followed by the aircraft to achieve a successful landing. I don't think it takes a very brilliant sooth-sayer to suggest that this dependence on earth control and the degree of automaticity associated with all its aspects will increase as time goes on.

In the case of military flying, these trends are even more pronounced than they are for civil flying. Take first, automatic flight. In the all-weather fighter of today the crew carries out its entire mission by reference to the indications of its own instruments. At no time, from the instant that the aircraft is 100 ft off the runway and throughout its entire climb to height, cruise out, attack and return to base, until it is again 100 ft off the surface of the earth, is it necessary for the crew to take their eyes off their instrument panels or to look out of the window at all. In fact, under difficult conditions, the crew are so busy with their instruments that they have no time to look out of the window, nor would they find looking out the window very much help in achieving their prime purposes.

**The Intercept Problem**

Even more marked is the increasing dependence of the all-weather fighter and even the day fighter upon ground control. Transport aircraft can still fly long distances over certain areas without undue concern about ground control and their position does not have to be too accurately reported until they reach the vicinity of the terminal. This is particularly the case in trans-Atlantic flying when an aeroplane can be 100 miles away from where it thinks it is and it does not really matter very much but, in the case of an all-weather fighter, the ground control does and must know precisely the position of the aircraft at all times and the aircraft must adhere exactly to the instructions from the ground. At the present speed at which air combat between the modern bomber and the modern all-weather fighter is likely to occur, the geometry of an interception is a very precise matter. It is not a matter of judgment but a matter of mathematics. There is a best path of approach, there is an optimum position at any instant of time which the fighter must be in with respect to its target and these paths and these positions are fairly precise in their limits. The amount of inaccuracy that can be tolerated and still achieve a successful interception becomes less as the speeds go up and it becomes less still when the speed advantage of the fighter over the bomber dwindles. The information available on the ground about the positions of the target and the interceptor at any time must be precise. The calculations which the ground makes using this information must be precise. The flying which the crew does on instructions from the ground must be precise. The team-work between the controllers and calculators on the ground and the crew in the air must be of the highest order to achieve a successful interception and kill. Air defence has become in the last few years a task of equal difficulty, both on the ground and in the air, and the ground controller and the aircrew are in fact equal partners, each dependent upon the other for the successful completion of a joint task.

**Divergent Trends**

I have been speaking for the moment about combat flying in the air defence role but, as you can all appreciate, air power in its proper sense has two aspects. Air defence is not enough by itself – there must also be air offence. It is in this striking power of the air that there lies the full meaning of air power. It is interesting to observe that, in military flying in the long range offensive role, the attempt is to reverse the civil trend and to make the offensive aeroplane as independent of the

ground as can be. This is not to be wondered at because you won't expect the enemy to co-operate with you when over his territory and, therefore, you will have to be able to get along without the use of ground aid of any kind. So here we have an interesting divergence in policies wherein the offensive weapons of air power are using all possible technical means to achieve independence and self-sufficiency for the air vehicle so that it can leave a given base, proceed to its target, destroy it and return without any help whatsoever from an outside source, while on the other hand in the defence, the greatest possible synthesis between the air vehicle and the ground control is being developed.

**The Modern Air Battle**

Because the air defence machine is so dependent upon its ground control element, it probably occurs to you that this offers an opportunity to an enemy to attempt to interfere with the linkage between the airborne vehicles and their control on the ground and even to deny the ground information of the whereabouts of the enemy and so blind the eyes of the defence. This introduces an aspect of military flying of course which is unique and which has no parallel on the civil side because normally in civil flying the only forces which attempt to interfere are the forces of nature, storms and static, and these can be predicted to some degree or avoided. But in military flying, this business of interfering with an enemy's information and sight by various forms of electronic skull-duggery, is becoming an increasingly essential tactic. It is here that electronics enter into the air battle in its most subtle and difficult form and it is here where the scientific brains and the ingenuity of both service and industry are challenged to the maximum degree. The details and techniques in this field of course are most highly classified and the only point in mentioning them is to emphasize to you the increasingly technical nature of the modern air battle. The air battle therefore is of a different order from the battle on the land alone or on the sea alone. It is of a different order in speed – this is obvious; it is of a different order in distance – ranging over hundreds of miles instead of tens of miles; and it is of a different order of technical complexity, a technical complexity which is compounded by the other aspects of terrific speeds and vast distances. It follows, therefore, that the demands made upon both the personnel and the equipment of an Air Force are quite different from the demands made upon the personnel and equipment of land forces or sea forces.

**A TECHNICAL SERVICE**

When all these trends and characteristics are considered, it is not surprising then to find that the Royal Canadian Air Force today is predominantly a technical service. One-fifth of all its officer personnel are practising engineers and approximately two-thirds are active aircrew, which, I have tried to show, is a technical occupation if there ever was one. Of the remaining people who are not active aircrew or practising engineers in the specific sense of having an appointment which is so labelled, about half are engaged either in the control of our existing inventory of weapons or in planning the nature of our future weapons. Now I have told you enough I hope about the technical nature of these weapons to make it self-evident that the people who control them today and the people who plan the types we should have in the future are also, in a real sense, practising engineers. You cannot deal with a problem as complicated technically as the problem of air defence or the problem of anti-submarine warfare in any other terms than technical terms. The logical course of action is no longer self-evident by mere casual examination of the obvious facts or by the use of hunches or by experience. The various components of an air defence system of today, the aeroplane, the weapons it carries, the devices it has in it to locate its enemy and aim its weapons, the devices on the ground to detect the enemy, the methods used for collecting the essential data and for making the necessary calculations – all these elements of the defence system are so inter-related that a change in one so affects the over-all performance of the whole system that we are forced to a new method of considering these problems.

**The Weapon System**

We no longer consider an individual weapon by itself, an individual aeroplane by itself or a radar station by itself but we have to consider them each in its turn as part of a larger complex, a weapons system, and, in deciding the characteristics which any one component must have, we have to analyze how effective the component will be with those characteristics when tied in to all the other components of the system which will exist at the time. Each of the major components has a number of variable characteristics and the variation in the characteristics affects all the other components of the system. Therefore, the problem of finding out what is the best device or specification to call up for a particular gadget in a particular portion of the system involves some very complicated procedures. For this purpose, we have enlisted the very welcome help of our scientists. What was in the last war an operational research section which attempted to define the best tactics for a special situation or which analyzed results of previous operations to try and devise improvements – this relatively simple procedure has now blossomed forth and become an important technique of the Air Force in planning what shall be done in the future. It is called Operational Analysis or Weapons System Analysis. Here the mathematics are applied to this system of variables from which an optimized system, a best combination of all the characteristics for all the components, is set up. This procedure is of course no mystery to any engineer in industry who has had to design any complicated gadget because all design is a study in compromise and I suppose our civilian friends will say to us that it is about time that the military got around to applying engineering principles to its military thinking. Well, we will accept that criticism with good grace and say "Yes, it probably is" but the engineering profession in their work at least have one advantage over the military – that they can do trials and tests on their designs and can prove them in use to see if their compromises are right. It is very difficult to give a real trial to a weapons system short of a shooting war and this, I think you will admit, makes the designers' problem or, in our case, the military planners' problem just a touch more difficult. However,

I can at least assure you that it won't be for lack of trying if the R.C.A.F. does not have the best possible combination of devices in its weapons system of the future. Long hours of debate and study, long hours of arithmetic and argument over months and months enter into a decision to adopt this or that particular device and the characteristics and requirements are continuously adjusted as the state of the art progresses.

**Reliability of Equipment**

There is one sidelight or corollary which comes to mind as a result of this increasing complexity of the air defence machine, which is common to all elements of air power but is probably most critical in air defence where the reaction time is so critical, and this is something which has occurred to all of you I am sure. It is the importance of the reliability of our technical devices. The most sophisticated and unerring weapon in the world is no earthly good if it just doesn't happen to be working when you need it or if it quits half-way to the target, nor is it any good to have a very complicated and sophisticated weapon if you have to have a party of Ph.D.'s to keep it running. So our ability in the Air Force to maintain the devices which we require is a definite limitation on our efficiency and effectiveness as a fighting machine. We have all been aware of the desire to simplify maintenance and we frequently specify that new devices shall be easy to maintain, self-checking, have a serviceability of such and such percent etc., but I think in the last few years and months it has become increasingly apparent that more attention must be paid to this aspect of our equipments if we are not going to trip over ourselves in our own complexities. After all it is better to have a bow and arrow that works than a musket that doesn't and we must face up to the fact that we cannot get so complicated in our devices that they cease to operate. Here is a field in which we need very greatly the help of industry – that they will design into the new devices which we need an inherent reliability, ease of checking and simplicity of servicing. The Air Force can specify these things, can demand them, but only industry with its ingenuity and its foresight can deliver them. To give you some idea of how much profit can be made by improving the reliability of our devices, let me tell you that today the average complex fighting aeroplane which takes off for battle and lands again for refuelling will, in an appreciable percent of the times, be unable to take off again immediately because of some unserviceability and, of the unserviceabilities which developed in those aeroplanes, a quite unreasonable number will take 3 hours or more to rectify. I am sure these things can be improved very materially if we put our collective ingenuity and brains to the problem and I am glad to say that there is an increasing awareness of this problem itself and of the dividends to be gained by solving it, both here and in the United States.

## SOME FUTURE TRENDS

**Men or Machines**

From this outline of the nature of the Air Force today, it is possible for us to speculate about the future in two or three broad areas. I have stressed the importance of ground control as a co-equal partner with the aeroplane in air defence. Today a great deal of the ground control is done by humans. There are many manual linkages in the chain of data handling and processing which goes on and the state of the art is such that, technically, computers and electronic devices of a similar kind can do a great deal of this work. The great problem to face the military in the future is how automatic to make the air defence system. Where will it pay to dispense with the man? Where is it dangerous to dispense with the man? I assure you that this problem is not a simple one. There are schools of thought which suggest that technology is sufficiently well advanced that the man can be taken away from most of the operations that go on and that a vast synthetic brain can do the whole job. I believe this school of thought is too extreme. There are many fields where computers have an exact and necessary place. In the handling of vast quantities of similar information, in the doing of arithmetic problems, in remembering the vast amounts of details, in correlating one piece of information with another, in transmitting information from one place to another – in these fields we all admit and welcome the amazing versatility and speed and efficiency of the electronic computer and other electronic devices and it is obvious I think to all of us that these must be our future tools. But where judgment is required, where the unexpected may happen, there, in our opinion, the human will not be replaced for a long, long time. After all, between our ears, we have a computer which has been under design and test for about 1,000 centuries and it is still the best of its kind yet devised and we in the Air Force would be very loath to throw away such a fine machine in favour of one whose development goes back only a few years. That is why we believe that man will still fly in the aeroplane of tomorrow and that is why the new supersonic fighter, now under design and development in Canada, will carry two men – not to do the routine but to exercise judgment and to deal with the unexpected. There are those who say that the next generation of fighters, such as the CF-105, will be the last fighters to carry men. We are reserving our views on this subject because much will depend upon the ability of the guided missile to demonstrate that it will be able in fact to do all the things that are promised of it. We are certain that the guided missile will complement a manned fighter in the defence system because certain conditions can be foreseen wherein the one is to be preferred to the other and vice versa. Guided missiles are not simple devices by any means and there will be long periods of development, trial and evolution before we will know precisely with how much of the burden of our air defence they can be trusted.

**Control of Civil Airways**

You will remember that I have pointed out a point of common interest between our air defence system and civil flying and that is that they both depend and are becoming more dependent upon ground control. As the air defence ground control mechanism becomes more automatic and sophisticated, it will have the capability, in my view, of dealing with all air vehicles flying over the air space of Canada and will be able to serve equally well the military and civil interests. I think it logical and self-evident that the radar stations, the communication nets and the computers, which together are necessary for

the air defence environment, will also some day help to serve the civil airways.

**The Partnership of Air Force and Industry**

There is no doubt that, as our air defence facilities and services become more complex, we will depend in increasing measure on the help of industry, not only to fabricate and overhaul but to maintain them. This raises the very interesting question of whether it is better for the country, in terms of effort and dollars, to do some military tasks by people in uniform or by industry. There has been heretofore a sort of axiom, accepted in some circles, that it is cheaper and more efficient to do a lot of these maintenance tasks by civilians and that the service should get on with the fighting and leave the engineering to industry. I think I have said enough, however, to suggest to you that the air fighting is no longer a non-engineering occupation and that the Service, to do its fighting, has to be just as immersed in matters of technology as is industry. I would question the axiom that it is always better and less expensive to do things by industry rather than by men in uniform. This is a matter which I believe should be examined in each case on its merits. I know that there are many examples where it is so but I also know of test cases where we have proven, to our satisfaction, that it is not so. An important problem, therefore, for us in the next few years is to achieve the proper balance between what should be done by the Services and what should be done for them by industry.

**Competition for Trained Men**

This poses some very difficult personnel problems for the Service. Competition for technical manpower in Canada is going to continue to be quite heavy; the papers lately have been full of the shortage of engineering graduates and the shortage of technicians and all of industry is aware of this. I have said enough about air defence and the Air Force in general to make it quite obvious that we too require a high level of technical skills in our personnel to exploit the very complicated devices and weapons which we will have to use. It follows therefore that we must continue to be able to compete for our fair share of the skilled manpower and of the potentially skilled manpower. We have the great advantage of course, in the Service, in that we have a very good training capability and, given good raw material and time, we can turn out excellent technicians. Once trained and experienced, however, can we retain them against the competitive bidding of the market? Our worries in this field would be less if we could be more sure that we were regarded by our industrial colleagues not as a competitor but as one of their best customers.

However this balance between service and civilian may come out, the fact remains of course that there always will be a partnership between the Air Force and the industries which support it. This partnership has become increasingly important and active, vital and efficient in the last five years, since we have begun not only to make things in Canada but also to design things in Canada. Part of this growth has been the formation and rapid development of the Canadian Aeronautical Institute as a professional society of stature, rapidly becoming recognized internationally. The Air Force is proud to have contributed materially to the formation of the Canadian Aeronautical Institute and to serve on its official bodies.

Air power today is our most important keeper of the Peace. We here present are all partners in Canada's contribution to North American air power. The challenge to keep this air power modern and efficient is a tremendous one and I am sure it is one that all the members of this Institute will accept with keenness and resolve.

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**Field Data Analysis**

*(See Pages 187 to 196)*

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# FIELD DATA ANALYSIS†

**by B. Larmour* and S/L J. E. Neelin****

***Royal Canadian Air Force***

## INTRODUCTION

IT is now generally recognized that ground and air borne equipment has become so complex that bench testing is no longer an adequate means of measuring equipment performance. Both design and procurement experts are looking to field data for the information they require.

David Hill of Hughes Aircraft must echo the concern of design engineers everywhere when he says "How good are the parts we now are getting? What does this mean in terms of system reliability? Not nearly enough is known about true operating performance of either parts or systems. It is obscured by wide variability in maintenance practices and competence and by lack of data that includes the all-important factor of operating time before failure".[a]

The R.C.A.F., as perhaps the largest user of costly and complex equipment in Canada, has a real stake in the search for better means of equipment evaluation. The difficulty has been, in the Air Force as elsewhere, with the analysis of field reports.

Recent studies on this subject have shed interesting light on the failure characteristics of various types of ground and airborne equipment. From these studies certain fundamental failure patterns have emerged and form the basis of this paper. These fundamental patterns have been recognized in other studies, particularly in electronic tube reliability and it is submitted that an understanding of failure patterns is a prerequisite for:

(a) the optimum procurement of equipment,
(b) its improvement through design and
(c) the determination of procedures by which it is maintained and overhauled.

## THE EQUIPMENT LIFE CURVE

The usefulness of field data analysis would be severely limited if it did not establish whether failures were due to a weakness in the equipment, or due merely to a variety of extraneous causes. If the first situation is confirmed then a modification to the equipment is required; but if failures can only be attributed to occasional chance factors then a modification to the equipment may yield no reduction whatsoever in failure arisings. The first task then of statistical analysis must be to make it possible for "weakness" failures to be quickly spotted and corrected. A first and useful tool at this stage is the Equipment Life Curve.

When equipment failures are plotted to show failures vs length of life in operating hours or other parameter, the envelope curve of this failure distribution may be called an Equipment Life Curve (EL curve). It is probable that most equipment is affected by all types of factors but in varying degrees of intensity so that perhaps the effects of only two or three will be significant. The predominance of one or more factors with a particular equipment class and the distribution of their effects through time establishes the characteristics of the EL curve for that class. Conversely an EL curve for a class of equipment can reveal the type or types of factor(s) causing failures at any point in the life of that equipment.

## FACTORS IN EQUIPMENT FAILURES

Useful distinctions can be made among the following classes of factors:

(a) *Design life factors* are those wear-out factors which are inherent in the equipment and which determine the intended operating life. They concern the mechanical, electrical and chemical deterioration of material as the result of equipment operation.
(b) *Inherent weakness factors* are those which produce failures as a result of consistently faulty manufacture, the use of inadequate materials, or of poor system or component design.
(c) *Age factors* cause deterioration of the material as a result of calendar time. Mandatory shelf life is necessary with some equipment because of age factors.
(d) *Incorrect usage factors* bring about equipment failures as a result of poor servicing, maintenance and operating techniques, or as the result of misemploying the equipment in work for which it was not intended.
(e) *Extraneous factors* are those of a transitory or accidental nature, quite unconnected with the equipment, its operation or maintenance.

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†Paper read at the Annual General Meeting of the C.A.I. in Montreal on May 4, 1956.
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**Logistics Programming Officer, Air Materiel Command.
[a]*The Reliability Dilemma*, ELECTRONIC EQUIPMENT, JANUARY 1956.

It is important to recognize that these factors cause failures which may be grouped about some particular operating life or may be randomly distributed through time.

### IDENTIFYING FAILURE FACTORS IN EL CURVES

When two or more factors cause failures in a class of equipment, the EL curves for that equipment may exhibit both normal and random distribution characteristics. Each has particular significance in the analysis of field data and their recognition is vital to the use of the EL curves.

The predominance of one factor is exhibited in the failure pattern for cockpit lights shown in Figure 1. This, of course, is merely a normal distribution about the mean. The conditions of the operational use of this item are relatively stable and this, tied in with the fact that quality control in manufacturing assures almost identical quality for each item produced, permits a reliable estimate of average operating life. Failures are primarily caused by filament failure. Filament life is built into the bulb and the predominance of this factor results in failures tending to occur at the design life.

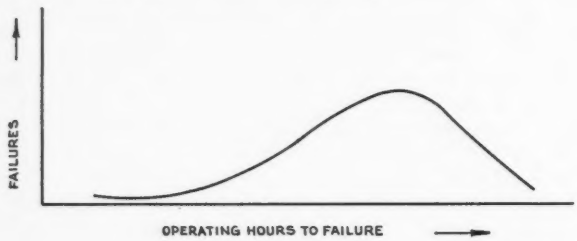



**Figure 1**
**Equipment life curve showing wear-out factor (cockpit lights)**

Under certain conditions, a sample of light bulbs should not be expected to conform to the normal characteristic failure pattern of Figure 1. A group of bulbs constantly being switched on and off, frequently jolted and jarred etc., is, of course, likely to have more failures in the earlier hours of use. These extraneous factors are as likely to have their effect at a life of one hour as at a life of ten thousand hours. A distribution of those failures would show not merely a lower mean life but a less evident normal distribution.

If these factors of rough and unpredictable usage are especially strong then it may well be the case that very few of the bulbs reach the design life experienced during bench testing under a more favorable environment. In this case the likelihood of failure becomes independent of the age of the bulb; there is the same probability of failure at one hour of operation as at the one thousandth hour. This constant probability of failure therefore applies throughout the life of the bulb.

For example, assuming this constant probability of a tube failing before it becomes one hour older, regardless of present age, it is obviously possible to forecast when, say, 90% of a sample of such items will all have failed. If this probability is 0.1 per 1000 hours (i.e. one chance in 10 of a tube failing through a further 1000 hours of use) then, of 100 beginning life at zero hours, 90 will be expected to reach 1000 hours, 81 to reach 2000 hours, and so on. It is a straightforward calculation then to

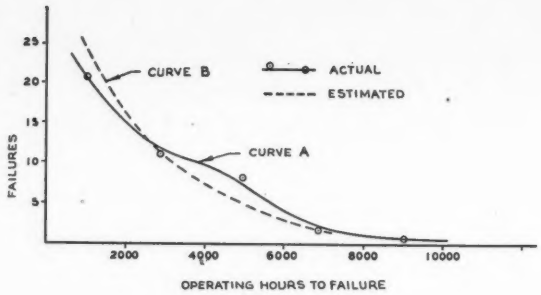



**Figure 2**
**Equipment life curve for 12AX7 electronic tube**

determine the mean hours to failure which is expected. This condition was encountered for some types of electronic tubes. Its effect is to create an exponential EL curve.

### THE EXPONENTIAL CHARACTERISTIC

Curve A in Figure 2 illustrates a typical failure pattern where any fundamental wear-out pattern and the corresponding normal curve are absent. Random factors bringing about failure of the item predominate to such an extent that they quite overwhelm such other factors as built-in life. The example shown is a frequency distribution giving hours at failure for the 12AX7 tubes.

The form of curve A is closely exponential ($e^{-x}$) which establishes either that the causes of failure are chance causes or that the causes of failure, perhaps there may only be one, are occurring at random time periods. It will be emphasized later that these characteristics have particular significance for the determination of maintenance procedures. Such a distribution signifies a constant probability of failure, regardless of the operating hours already on the equipment. The value of this constant probability of failure will of course vary among different types of equipment and will rarely be the same for one component or piece of equipment in different environments.

Only one parameter is required to establish the slope of the curve (and therefore the probability of failure) and that is the mean time to failure. The mean life, calculated from this sample, is 2600 operating hours.

Curve B, the dotted curve in Figure 2, is a theoretically constructed curve. It was drawn by calculating several values of $e^{-x}$ ($e$ being the constant 2.718 and $x = \frac{t}{m}$, where $t$ is operating hours on tube and $m$ is mean life of 2600) and so fitting a curve.[b]

As can be seen, this theoretical curve falls close to the curve of actual field failures. Although failures may

[b]This is merely the use of the Poisson distribution.

$$P_r = e^{-z}\frac{z^r}{r!}$$

Where $P_r$ = the probability of $r$ failures
$e.$ = 2.718
$z$ = No. of failures expected—which therefore equals $t$, operating hours, divided by $m$, the mean life.
$r$ is put equal to zero since it is required to calculate the probability of a tube lasting to $t$ hours before failure. Consequently the expression becomes $e^{-z}$ which can be rewritten $e^{-\frac{t}{m}}$.

be random through time, and studies on the subject suggest this is so with much electronic equipment, yet effective analysis should lead to a useful approximation in forecasting failure arisings.

Table 1 gives a comparison of estimated and actual failures for two tubes the 12AX7 and PL522 — a test which was carried out as part of these present studies.

Table 1

Comparison: Actual Failures vs Theoretically Estimated Failures

| | OPERATING HOURS | | | | |
|---|---|---|---|---|---|
| | 0-500 | 0-1000 | 0-2000 | 0-3000 | 0-5000 |
| 12AX7 Tube | | | | | |
| Estimated failures: | 8 | 14 | 24 | 31 | 38 |
| Actual failures: | 5 | 12 | 22 | 26 | 42 |
| PL522 Tube | | | | | |
| Estimated failures: | 6 | 10 | 17 | 21 | 28 |
| Actual failures: | 3 | 12 | 17 | 20 | 25 |

Only small samples provided the data shown in the table above. All available returns were included, however, so that there was no process of selection. There is some difference between actual and estimated failures, but the point which it is intended to emphasize is that these failures bear no relation to a normal distribution — they follow an approximate exponential distribution.

It is possible to calculate the constant probability of failure if the mean hours to failure is known. The only parameter to the distribution pattern for failures with equipment under these conditions is the mean life; given this, the whole expected pattern of failures can be stated. It becomes possible therefore to identify this distribution with the well known 'exponential' distribution since the only parameter to the latter is also mean life. In this it differs from the normal distribution where mean life is insufficient to determine the distribution, standard deviation being the other required parameter.

A particular usefulness of failure distribution analysis with this sort of equipment is that field experience over a limited number of operating hours permits early forecast of the mean life and other characteristics, before a single item has actually been in service for a period as long as mean life. This is particularly important in these days of complex equipment when field data are an essential complement to bench testing and early feedback of conclusions from the analysis of field data is required.

It should be pointed out that the extrapolation of a failure pattern established by early failures is not a feasible way of forecasting the envelope shape of the EL curve, which would materialize after a sample of the tubes had all operated to failure. Statistical tools proposed later in this paper however would enable early failures to be translated into Marginal Failure Probability rates (referred to afterwards as MFP curves or rates, which express the probability of an item failing before it has passed through the next hour or other period of use, i.e. the probability that, having reached any particular hour of use, the item will fail in moving from this margin to the next margin one hour later). EL curves can then be developed from the appropriate MFP curve.

Besides the importance of feedback for early improvement through redesign, it is of great help to the using agency, which is thus enabled to establish realistic

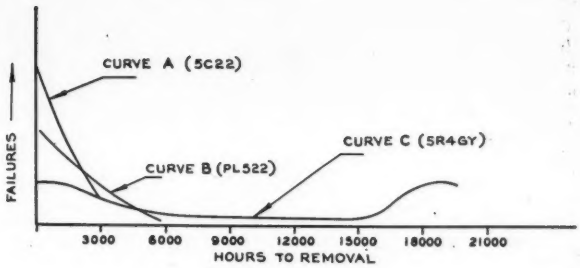



**Figure 3**
**Equipment life curves for electronic tubes PL522, 5C22, 5R4GY**

spares requirements. Also, early comparison can be made of substitute components or assemblies and a sound decision made, on the basis of MFP rates, as to which equipment type is preferable in the particular configuration and environment.

Figure 3 shows the smoothed approximation of failures reported on the 5C22 and PL522 for one type of equipment. These tubes are substitutes in this application. There is a clear adherence to the exponential in these failure patterns, as there was for the 12AX7. Apparently the performance of the PL522 tube is superior in this application.

The failure pattern for electronic tubes is, however, not always exponential. The random nature of failures becomes much less marked when a tube is operating under fairly stable conditions and the system operation has passed beyond the "debugging" stage. Field records on the 5R4GY tube, a common rectifier, reveal a weak chance effect in failure occurrence and an emergent normal hump around the 20,000 hour level. This is also shown in Figure 3.

Taken together, the three curves in Figure 3 illustrate the dynamic nature of mean operating life for equipment in this class. The curve for the 5C22 falls very sharply, indicative of a high MFP curve; the improved performance of its substitute is shown in the slower decline of the curve for the PL522 while the non-exponential curve for the 5R4GY shows the performance characteristics of a tube which is operating to a wear-out stage.

## COMPLEX EL CURVES

The curves shown in Figures 1, 2 and 3 are each typical of different classifications of ground and airborne equipment. Some equipments, however, inevitably experience quite unique failure patterns which, though having the same fundamentals as shown in Figures 1, 2 and 3, are more complex.

Aircraft engines are a prime example. Because of their complexity, there are many factors influencing failure yet failures do not tend to be distributed randomly through time. As operating experience is gained, basically weak parts are revealed, parts whose functioning is unsatisfactory and which cause failure groupings around the time-on-engine when the weakness becomes critical. Curve A of Figure 4 illustrates this; the "normal hump" at point X is a grouping of failures attributable to a significant weakness in the engine. Curve B on Figure 4 represents a distribution of failures at a later date, by which time the modification programme to correct the

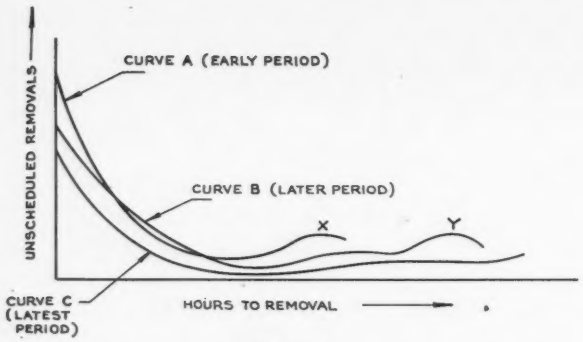



**Figure 4**
**Typical EL curves for an aircraft engine through different time periods**

weakness occurring previously at point X has begun to have its effect. The hump at point X is smoothed out, a greater percentage of the engine type are continuing without failure beyond this point and a further significant weakness is being met this time at point Y about which a failure grouping shows itself in the familiar "normal hump". Curve C, the latest of the three distribution patterns, begins to show the smoothing of the hump at Y, as those weakness factors are overcome, and the encounter with a further weakness at a later time-on-engine.

The dynamic movement through calendar time, from a higher to a lower failure curve, which typifies the experience with such complex items as aircraft engines, is represented in curves A, B and C in Figure 4. This results not merely from the smoothing of successive "humps" as described above but also from the lowering of failure arisings in the first few hours of time-on-engine. Initially, the lack of experience in the field with a new piece of complex equipment and certain deficiencies in manufacturing and overhaul give rise to a high "infant mortality" experience. This is represented in curve A of Figure 4 where failures in the first few hours of an engine's use are high. Through time, however, a substantial decrease in these types of failures is brought about and, as shown in successive curves B and C in Figure 4, moves the failure curve to a lower plane.

Treated as an economic problem, the optimum time-to-overhaul on an engine could be regarded as that point along the failure curve when the cost of overcoming the next "hump" (i.e. of designing, manufacturing and introducing a successful modification) is more than the saving in overhaul costs resulting from the consequent reductions in overhaul arisings. However, safety factors are of course critical here, depending on the nature of the failure influence and on the Marginal Failure Probability curves discussed in the next section.

Before proceeding however we should examine one other particularly interesting and useful application of the EL curve – vendor comparison. The following example illustrates its effectiveness in analyzing alternative vendor products and services.

A recent EL curve for artificial horizons exhibited a grouping of failures around an early operating hour level which tailed off until a rising number of failures began to characterize the distribution towards the time for overhaul. Figure 5. The correlation of failure with overhaul contractor showed that the failure probability for the horizons overhauled by contractor A was much higher in the early time interval than the corresponding failure probability for horizons overhauled by contractor B. A breakdown of failures by cause showed that failures about the early interval were largely attributable to a substandard part. On reporting this to contractor A, it was discovered that the subcontractor who supplied him with these parts was not the same one supplying them to contractor B. On switching subcontractors, company A experienced much better performance and the R.C.A.F. had fewer artificial horizon failures.

## MARGINAL FAILURE PROBABILITY CURVES

The failure characteristics of equipment types considered in this paper can be very useful in the form of failure probability curves. Most commonly used in the actuarial field, the technique of probability curve analysis is becoming increasingly popular in logistics where new components, complex systems and the alternatives in many complex plans require a measure of probable outcome to permit rational action. The term Marginal is used to describe these curves because they are calculated by summing the number of items which successfully passed through the marginal (i.e. succeeding) hourly interval and dividing this figure into the number of items which failed when being operated in that class interval. (There are actually some necessary refinements in the calculation.) It then becomes possible to express the probability of marginal failure just as it is possible to calculate the probability of a man aged 27 dying before he is 28 (contrasted to the overall probability of a newly born child dying before he is 28).

MFP curves derived from the distributions in Figures 1, 2 and 4 are reproduced in Figure 6. Curve 1, derived from the normal curve pattern of Figure 1, shows the ascending probability of failure as operating hours on the equipment become higher. This characteristic is important for equipment reliability. As the reliability of a system is largely dependent upon the failure probabilities of its components, it would be possible to achieve high system reliability by installing components with low operating hours if these components were in the group classification displayed in Figure 1.

If the component parts were in the classification shown in curves A and B of Figure 3, however, the associated MFP curve is given by a horizontal line such as 2 in Figure 6 and the reliability of the system would be independent of operating hours already on the components. The actual rate of failure for each of the ex-

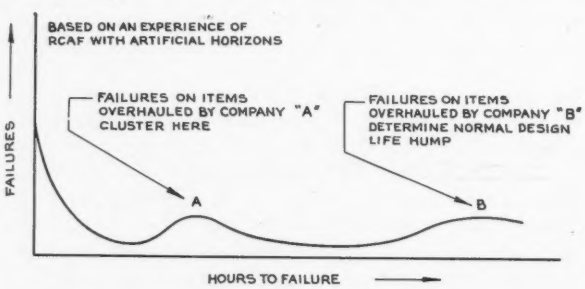

BASED ON AN EXPERIENCE OF RCAF WITH ARTIFICIAL HORIZONS
FAILURES ON ITEMS OVERHAULED BY COMPANY "A" CLUSTER HERE
FAILURES ON ITEMS OVERHAULED BY COMPANY "B" DETERMINE NORMAL DESIGN LIFE HUMP
FAILURES
A
B
HOURS TO FAILURE

**Figure 5**
**Vendor comparison by EL curves**

ponential curves A and B of Figure 3 is different of course but each rate is constant. It will be appreciated therefore that equipment whose failure probability curve approximates the horizontal line of 2 in Figure 6 faces no greater risk of failure at, say, 10,000 hours of operation than at 10 hours and should not be subject to automatic replacement after any set period of operation.

Curve 3 in Figure 6 is the derived MFP curve from field failure data shown in Figure 4. The R.C.A.F. has recently introduced a refined technique (the A.M.C. Actuarial System for engine analysis) to put such derived curves to practical use. The advantages of such analysis are many but in particular a direct comparison can be made immediately between the probability of equipment failure at any hours-on-equipment stage and the probability of failure if a replacement were put in either from new or overhaul. Obviously it may be inadvisable to set a mandatory time-to-overhaul on a piece of equipment at 1000 hours of operation if the probability of its failure, if it continued to 1100 hours, were to be lower than the failure probability its replacement would have to face in the first few hours (the well known "infant-mortality" field experience). For example, if 100 altimeters each with 1000 hours on continued to 1100 hours and so were exposed to a failure probability of 0.02 per 100 hours, then 2 altimeters may be expected to fail before the survivors have each completed 100 additional hours. But if these 100 altimeters were, instead, sent for overhaul automatically at 1000 hours and replaced by 100 altimeters fresh from overhaul, then an applicable failure rate of 0.05 through the first 100 hours of operation would give the expectation of 5 failures by the time the survivors had each completed 100 hours. Early overhaul in this case is clearly undesirable and uneconomical. The measurement of these characteristics is therefore a necessary guide in establishing maintenance procedures and, in turn, replacement procurement since the frequency of overhaul determines the number of spares which must be bought.

## FIELD DATA RELIABILITY

In the course of these studies on equipment failure patterns, it has been possible to draw some useful conclusions regarding the reliability and quantity of data required to establish the fundamental characteristics of equipment systems and components in the field. There are of course many accepted statistical techniques for sample size determination and the significance testing

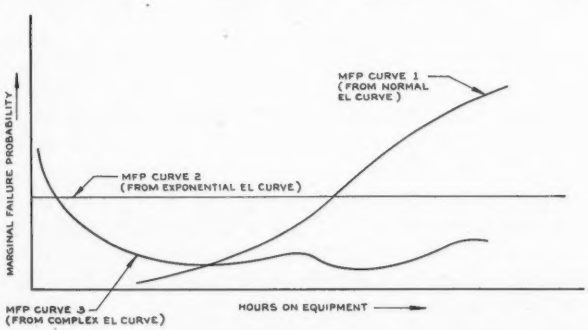

MARGINAL FAILURE PROBABILITY
MFP CURVE 1 (FROM NORMAL EL CURVE)
MFP CURVE 2 (FROM EXPONENTIAL EL CURVE)
MFP CURVE 3 (FROM COMPLEX EL CURVE)
HOURS ON EQUIPMENT

**Figure 6**
**Marginal failure probability curves derived from Figures 1, 2 and 4**

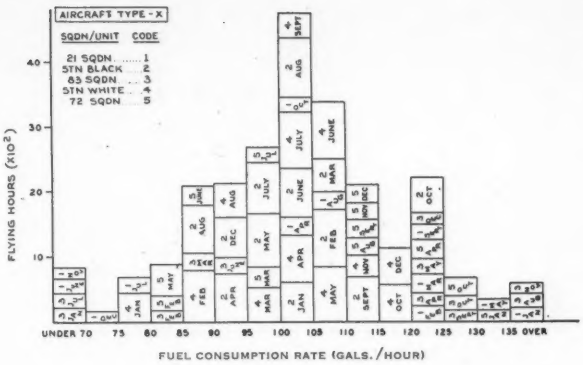



**Figure 7**
**Distribution of different unit fuel consumption average rates for one aircraft type**

of results, but it is necessary to employ these very carefully when the data being returned are from field personnel who have little sympathy with paperwork.

These criticisms of data reports from the field are commonly heard and often held sufficient to nullify the usefulness of conclusions and recommendations arising from their analysis. The most satisfactory way to reach conclusions on the accuracy of field data would be to calculate statistical measures from the field data and then check them with the actual proven values established from an independent source of known reliability.

It is not often possible to devise such a test since it is unusual to have a thoroughly reliable independent source whose data can be used as a basis for evaluating field data. However, such an opportunity arose lately in a comprehensive study, carried out by the authors, of aircraft fuel and engine lubricating oil consumption. The particular importance of this study to the contribution of this paper is that evidence was provided to permit judgment on the application of standard statistical techniques in the analysis of field data.

Briefly, a complete set of fuel consumption rates (per flying hour) was established by statistical means from highly suspect field data. These rates were applied to the flying hours accomplished in a different period and the resulting estimate of R.C.A.F. total fuel consumption for one year was less than 1% away from the actual figure of fuel used. It can be concluded that whatever averages were determined from the survey were reliable averages. And yet there were a great many factors tending to conceal these averages – errors in reporting, omissions and plain "rigging" of returns.

Similarly, in any field data analysis, there are always factors present which seem so special as to appear to discount the value of derived statistical measures such as averages. In this case, distribution pattern analysis was found to be most useful. Consider Figure 7 for example. It is a distribution chart showing the fuel consumption averages derived monthly through a twelve-month period from many R.C.A.F. units flying a certain type of aircraft. (Representative figures have been entered on the chart to avoid disclosing classified information.) Since 5 units were reporting for twelve months, 60 average rates were derived. Each average was plotted on the chart in the appropriate class interval and the ordinate weighted

according to the number of hours flown in the month from which the average was calculated. Thus, if 200 hours were flown at one unit on this aircraft type and the log book showed a consumption of 20,000 gals of fuel on these aircraft in this period, then the average (of 100 gals per hour) was entered in the class interval 100-105 gals per hour and weighted by the factor of 200.

From these 60 returns a distribution pattern was built up. In the case of fuel consumption-charts the returns were distributed in an approximate normal pattern about a mean rate. This established that there was a stable fuel consumption rate which could be used for forecasting purposes. The effects of season, geographic location, squadron role, etc. on fuel consumption could be observed by noting the deviation from the mean which these subsidiary factors brought about. The wide range of these plotted averages is not only attributable to these factors however. Many inaccurate returns were submitted for which the derived averages were often a long way from the mean.

The important thing to be observed from this study is that if a strong correlation exists between two or more variables, then the effects of inaccuracies in field data will be negligible unless a sustained bias is present in the field returns. However, it is not the suspicion of deliberate bias which is at the root of most lack of trust of field data analysis but rather it is the knowledge of random errors in reports. Therefore, in the absence of sustained and widespread deliberate falsification of field returns, a sufficient sample of returns can be expected to clearly reveal a characteristic when it is a strong one. Inasmuch as a request for redesign, or an extension of time-to-overhaul can only be justified when the relevant characteristics have been strongly established, it therefore is submitted that the usual sort of errors arising in field reports are of small consequence.

The elementary procedures for estimating sample size are not too satisfactory in the sort of work covered by this paper because of the associated factor of data reliability which is often an unknown at the start of a study. Sample size cannot be independent of data reliability. The tools described earlier in this paper for data analysis are meant to give a picture of equipment behaviour at the earliest possible time. If the field data are supplied completely and accurately then a shorter time will elapse before operating characteristics can be determined; if the data are less reliable and incomplete then a longer time will pass before significant relationships can be concluded from the data analysis. It should be recognized, therefore, that field data with suspected errors and omissions are unlikely to establish false correlations which are statistically significant. The prime effect of ordinary inaccuracies in field data is to extend the data reporting period required before significant characteristics can be clearly recognized. Equipment Life Curves almost inevitably are constructed from data which contain errors, but EL curves are tools for establishing important factors, not for yielding precise measures of subtle and complex relationships. Significant equipment characteristics usually emerge from effective analysis regardless of random errors and omissions in the basic data. The very fact of their significance is established if they do emerge and the fact of their insignificance is established with rare exception if they do not emerge.

**UNSTABLE POPULATIONS**

The importance of EL curves and MFP curves arises from their usefulness in revealing the operating characteristics of equipment. Both curves can be easily derived from a stable population, (i.e. a population whose number is not changing more than very slightly and whose age distribution remains fairly constant). Simply plotting the failure distribution of a representative sample of items produces an EL curve and this is equivalent to plotting a sample number of failures in any one time period from a stable population. The MFP curve can be immediately derived when the EL curve has been constructed.

An illustration will show how the failures arising from an unstable population would give a most misleading picture of equipment life if they were plotted in distribution form and assumed to be EL curves. Suppose that 27 items of one equipment type enter service (simultaneously) for the first time. Suppose further that after 100 hours of operation for each set, ⅓ of the population have failed, and that in succeeding 100 hour intervals ⅓ of the population fail in passing through each interval (i.e. the MFP rate is constant).

Figure 8 shows the changing age distribution of the population as operating hours increase and failed equipments are replaced by others fresh from manufacture or overhaul. It also shows how the distribution of failures in any one time interval can change radically on account of an unstable population. When the surviving equipments have passed through the first 100 hours of use, the equipment population distribution will show:

9 with less than 100 hours (being the 9 replacements for the ⅓ of 27 that failed)

18 in the 100-200 interval (having survived 100 hours of operation).

When survivors and replacements have each passed through a second period of 100 operating hours, the equipment population distribution shows:

9 with less than 100 hours (being the replacements of 3 failures in the 0-100 hours interval plus six replacements for the ⅓ of that 18 that failed in the 100-200 hours interval).

6 in the 100-200 hours interval (having survived 100 hours of operation).

12 in the 200-300 hours interval (having survived 200 hours of operation).

Figure 8 clearly shows the differing failure distribution pattern resulting from population instability.

Consideration of this matter is worthwhile because a quite erroneous impression can be caused by failure charts if full account is not taken of the population distribution. Some of the most impressive reports coming into A.M.C. from contractors show failure charts which do not take this into account and are consequently incorrectly interpreted. This is particularly critical because mean life can appear to vary radically from one period to another when in fact the mean life is constant – the illusion of change being due solely to unstable population distribution.

It is common practice for mean life to be calculated by totalling the hours on all failed and time expired equipments in any period and dividing this figure by the

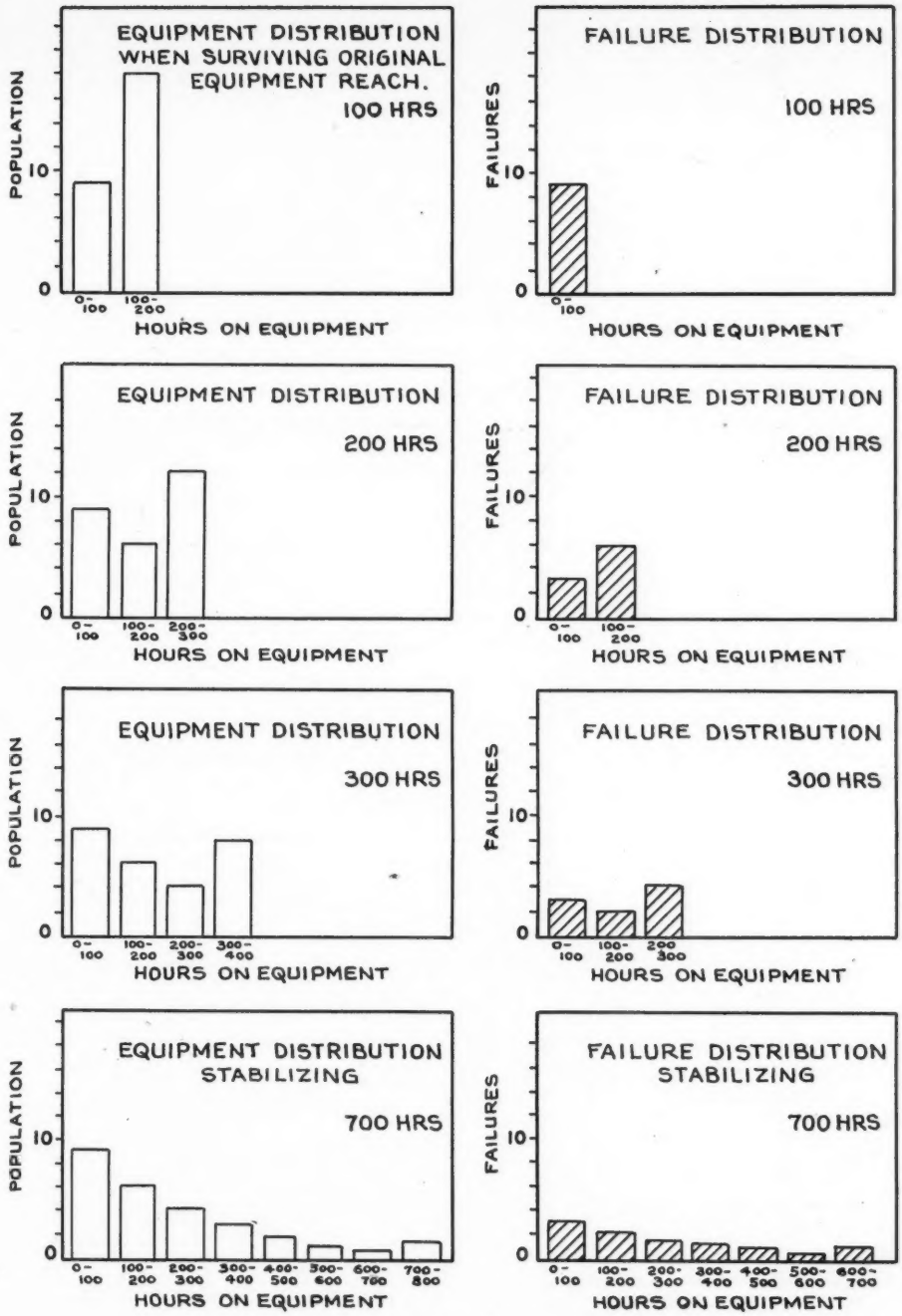



**Figure 8**
**The distribution of equipment population and failures for an unstable population through different time periods**

number of these equipments. Thus, in the example of Figure 8 the calculation of mean life when no equipment had more than 100 hours on would be the division of 9 (the number of equipments which failed in this period) into 450 ($9 \times 50$, assuming the nine failures occur evenly through the interval and therefore averaging 50 hours each). The mean life would be given as 50 hours.

For no other reason than that the population is unstable, the mean life when the equipments have operated a further 100 hours will appear to be higher. In the case shown, it will be 116.6 hours. It would be quite false to assume from these figures that the equipment is doing any better at the later time than when the earlier average was calculated. And yet the higher average life (116.6 hours vs 50 hours) can give that impression to a person unfamiliar with the population instability.

The discussion above has centered on an illustration which is extreme. It is nevertheless a fact that some of

the contracting companies calculate the mean life of their equipment in this way and regard the changing average as a reliable indication of product improvement when population instability could be the prime reason for a shifting average.

There is, however, a means for determining equipment failure characteristics for unstable populations.

Because the MFP curve is independent of the age distribution it is a useful tool for indicating product improvement or deterioration. It is more preferable in this application than either mean life or charts showing the distribution of failures. (A statement that the probability of an equipment failing before it reaches 100 hours is now 0.02 when a year ago it was 0.09, gives a more correct picture of equipment use improvement than the statement that 65 equipments failed in this interval last year compared to 71 this year.)

As emphasized earlier, the period when an equipment type is new in the field is the time when significant statistical measures of its performance would be very useful. It is also a period however when the population is unstable because the age distribution is changing rapidly. Frequency distributions of failures will therefore not be of much help for reasons given above. Mean life will be of little help for the same reasons. The MFP curve is at this time the most useful of the statistical tools available. It permits immediate comparison between new equipment types and others which have been in service longer. It is a help in estimating mean life before equipment has operated for that period and it gives an indication of what failures will be arising in the future.

To calculate the MFP curve, it is necessary to have data on both failed and non-failed equipments. The failure rates by time interval are calculated and plotted to form the MFP curve. Without this information the failure probability rates for unstable populations cannot be calculated and it is not possible to arrive at any significant statistical measures in the early stages of new equipment coming into use. It should therefore be recognized that a carefully planned field data reporting system is of particular importance at the time of introducing new equipment into the field if the interpretation of its field performance is to bear any real significance.

## MACHINE PROCESSING TECHNIQUES

As has been emphasized many times through this paper, analysis of R.C.A.F. field data serves both the R.C.A.F. and the supplying companies. The former require it for guidance in procurement, system and component improvement, the determination of most satisfactory maintenance procedures and stock levels, vendor comparison, etc. Rapid feedbacks of meaningful data to our supplying companies enables them to effect product improvement.

The methods used in machine analysis must, therefore, relate strictly to the accomplishment of these desirable goals.

In carrying out the research of which this paper is a summary, the authors developed the conviction that, wherever possible, a lengthy machine print-out of failures should be replaced or supplemented by a chart. One chart, if simple and meaningful, will do a job for management control that 50 papers of closely machine

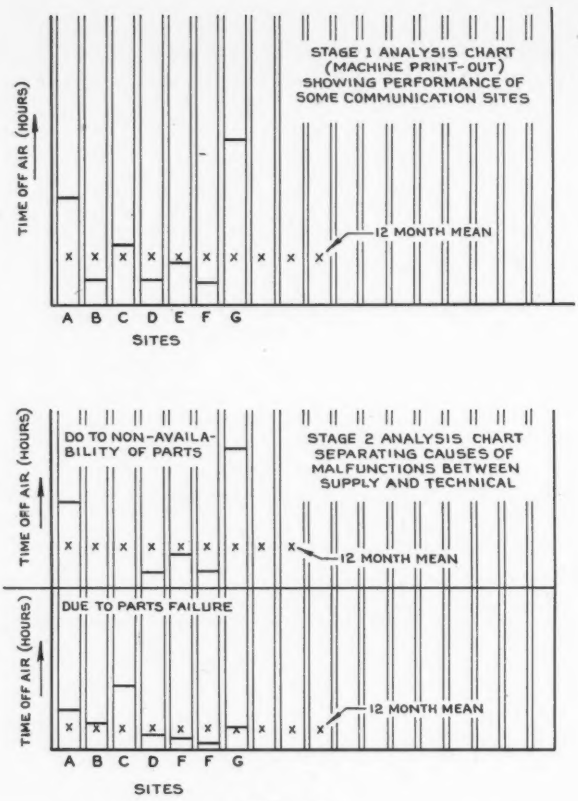



**Figure 9**
**Typical management control machine print-outs**

printed sheets do not do. For example, compare the usefulness to management of the simple chart print-out shown in Figure 9, with the alternative 16-page listing. To interpret the chart would occupy management hardly more than a minute since the important points stand out clearly. That one minute permits an estimate of whether the situation is in hand or calls for correction. To ask management to scrutinize a closely printed 16-page listing however is quite unrealistic. Yet nowadays many critical series of reports are tabulated on machines and distributed only in this tabular form.

It was a purpose of the studies under report to examine the possibilities of machine analyzing (these masses of data) to print-out simple effective charts to serve as management guides.

Unquestionably there will be accelerated developments in this field of analysis during the next few years as data processing becomes increasingly mechanized and thereby permits the analysis of mass data to an extent not previously possible.

### The Reporting Document

Machine recording and machine tabulating for all field data returns is not yet universal in the R.C.A.F., but it is the way that the bulk of inflowing data is handled.

Experience has shown that great care has to be taken in deciding on the layout of the source document itself. Whenever possible, it is desirable that there should be no transcription from the source document since this is time consuming and a common source of error. The

field malfunction reporting form for electronic equipment, coming into use in the R.C.A.F., is a machine card intended not merely as the source document, but also the working card at the machine analysis level. One such card is sent in from the field for each electronic failure. Complete details regarding the item, its circuit position, its assembly etc., are recorded by simply checking with pencil the appropriate space in the card. Additional details can be put in narrative form on the reverse side.

Particular advantages to this sort of form are:

(1) The form is filled in by the maintenance man in the field and is not merely derived from supply records.
(2) The form is self-explanatory. There is no need for instructions on how to complete it.
(3) The ease of machine sorting contrasted to the tremendous job of manually sorting thousands of cards a month is an obvious advantage.
(4) Since the source data document becomes the working card in A.M.C., this means that whenever a sort is carried out to extract failure cards with some common characteristic, the actual cards which were completed in the field are extracted. This is important because the field men are asked to write additional comments regarding the failure on the back of the reporting card. This narrative report would have to be transcribed onto the working card if the source document were not retained as the working card. A lot of key punching and transcribing time is saved through this procedure.

To do an effective job of data recording, data analysis and feedback of results, machine procedures are much more than a help; they are a necessity if maximum use is to be made of reports from the field, particularly if the volume of these reports is heavy.

The machine calculation of plotting points for EL curves and MFP curves is a great time-saver. Where the manual calculation of MFP curves for one equipment type is currently taking ten man-days in A.M.C., a trial test on the same data on machines gave the required output in less than an hour.

**Effective Analysis**

Current research into the possibilities of developing machine processing of data is aiming at a complete machine analysis and a machine print-out of summary charts. The first 4 stages of this approach are as follows:

*Stage 1*

This stage of analysis is intended primarily to serve management. It involves the calculation of some measures which reflect the overall operating performance of equipment types at different units.

For example, Figure 9 gives such a measure for ground communication units. Time-off-air on account of breakdown is the basic data. Current returns from different units are compared to each other and to a twelve months' average. At a glance, management can see whether the overall picture is good or bad and which units are relatively worse than others.

*Stage 2*

The second step is a general classification of malfunction causes. It is of assistance to management and to technical and supply personnel. In the case of the communication units given above, the general classifications are:

(a) time-off-air on account of parts failure, and
(b) time-off-air on account of non-availability of spare parts, Figure 9.

This breakdown indicates whether time-off-air is primarily caused by technical weakness or by inadequate supply procedures.

*Stage 3*

This stage takes the malfunction analysis into particular component classifications so that there is a clearer understanding of the relative number of breakdowns due to these classes. Attention is thus directed to critical component classifications where improvement could effect the most significant reduction in malfunction arisings. To continue with the communications example, the chart print-out shows:

(a) number of failures due to tubes,
(b) number of failures due to relays,
(c) number of failures due to capacitors, etc., Figure 10.

These sorting processes, lengthy if done manually, are of course very quickly done on machines. At this stage it is possible to trace an unsatisfactory time-off-air record (as shown in Stage 1) right down to the classes of parts which are primarily responsible. (Unless Stage 2 shows the cause to be poor supply.)

*Stage 4*

For those parts' classifications which exhibit a high number of failures at Stage 3, analysis proceeds in more detail through Stage 4. Figure 10 shows the frequency of failures attributed to component type (Stage 4A) and

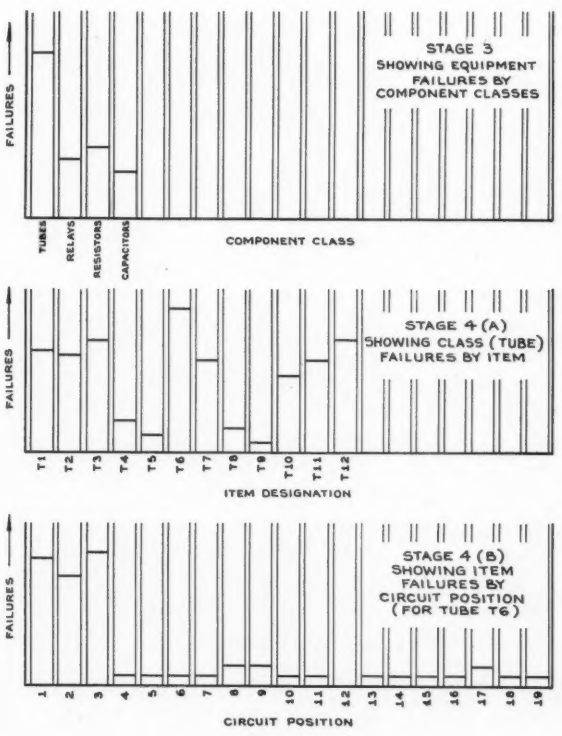



**Figure 10**
**Component failure analysis charts**

to actual circuit position (Stage 4B) for tubes, since tubes were seen at Stage 3 to be causing a high number of failures. Thus, unsatisfactory time-off-air can at this stage be related directly to critical circuit position.

The four stages mentioned above have application to the analysis of many series of field returns. They carry the examination from general measures for management control under Stage 1 to the detail required for effective correction in Stage 4.

But these steps go only part of the way towards the optimum use of machines for field data analysis. As an added measure for usefully interpreting the charts shown when considering the earlier stages, it is intended to calculate "normal limits" to reveal when field malfunctioning is *significantly* out of normal. Attention is then directed to abnormal failures. The normal arisings, which are of less critical importance, retire into the background. These limits would appear on the charts you have just seen and abnormal malfunction data would appear as points outside the limits. The method for calculating these limits is straightforward, the same way that quality control limits are established in many industrial applications.

Emphasis is required here on the need for setting these normal limits as a measure of field performance. A great deal of material purchased has passed rigorous quality control tests before moving out of the manufacturer's plant. But these tests only assure a standard of quality at the time the parts pass from the manufacturer to the operator. The performance of parts when they are introduced into field systems can vary widely; an electronic tube in one system application may have a mean life of around 1,000 hours when the same tube in another application may have a mean life close to 10,000 hours. The usefulness of statistical quality control in revealing abnormal quality in production has long been accepted; its extension through machine processing of field data to reveal abnormal field performance is a natural step.

Consider also the importance to the design engineer of knowing the actual operating limits which have been experienced with particular components and systems in actual field use. The following is a quotation from a paper by Harry B. Brown of Aeronautical Radio Inc. to a National Symposium on Electronics Reliability in Washington this year.

> "All of us who are working in the equipment reliability field today are looking forward impatiently to the time when calculations will replace guesswork — If the reliability of a new equipment (or a new system) is to be predicted with reasonable accuracy while the equipment is still in the design stage it can only be done on the basis of the known performance of component parts."

**SUMMARY OF APPLICATIONS**

In conclusion, here are some important areas of activity and a summary of the effective use in these fields of the analytical methods discussed in this paper.

(a) *Management Control* — The aim is machine analysis of mass data and the derivation of key performance indicators printed out in simple chart form. Figure 9 was shown as an example in the communications field, the key indicator being time-off-air by units. The machine calculation of "normal expectation" limits and their print-out on the chart is an added feature designed to draw attention to out-of-normal conditions.

(b) *Equipment Design* — The value of field experience feedback to designers is fundamental and of increasing importance as test bench experience becomes less practical with increasing equipment complexity. The difficulty has been the interpretation of raw field data in significant terms. It is submitted that EL curves and MFP curves are necessary tools to achieve this interpretation. The electronics reliability problem has reached such dimensions that several international meetings a year are taking place solely to discuss it. The most recent was attended by over 1,000 electronics engineers and the centre of discussion was the development of field data analysis.

(c) *Initial Procurement* — The accurate calculation of how many spares to buy to support any programme of ground or airborne activity is a difficult matter. It is most difficult to make a reliable estimate when the item to be purchased has never previously been in service because, in that case, there is no guidance from field data. In some cases however a small quantity can be initially procured (usually at a higher unit price) and put into service. The early derivation of a significant MFP curve from field experience with the initial quantity will permit a more reliable estimate of the need and an order for the required balance can be placed at this later stage.

(d) *Inventory Control* — The methods described in this paper are essentially to assist in revealing the operating characteristics of different types of equipment. This knowledge is a prerequisite to good inventory policy. The setting of min/max levels can be haphazard without reliable usage rates and achieving this reliability is a problem of correctly analyzing field returns.

(e) *Maintenance* — The importance of MFP curves for guidance in establishing optimum time-to-overhaul on repairable equipment was discussed earlier. The effect of different maintenance procedures is another important observation which these curves and EL curves make possible.

(f) *Vendor Comparison* — One other difficult problem facing user organizations is the evaluation of substitute or alternative items. EL curves provide a reliable means of performance evaluation on the basis of which can be made rational selection of best buys.

Improved equipment performance is the real aim of field data analysis. It is hoped that further developments in data reporting and data analysis will enable us to keep pace with the accelerating need for rapid and reliable measures of systems and equipment performance.

# THE COMET 4
# DESIGN AND OPERATIONAL CONSIDERATIONS†

**by R. E. Bishop* and G/C J. Cunningham****

***The de Havilland Aircraft Company Limited***

## INTRODUCTION

THE Comet 4 has been developed from the Comet 1, 2 and 3 and is the result of the continuous and intensive development of the jet transport aircraft over the last ten years. During its two years in service with B.O.A.C., U.A.T., Air France and the Royal Canadian Air Force, the Comet 1 flew on the airlines for over 30,000 hours, or, putting it another way, it covered over 12,000,000 miles, which is equivalent to roughly 500 times round the world. The major part of this experience was obtained on the B.O.A.C. routes between London, South Africa, Singapore and Tokio. It should be remembered that this invaluable operating experience is still the only practical experience of operating the straight jet aeroplane in airline service on the world's air routes.

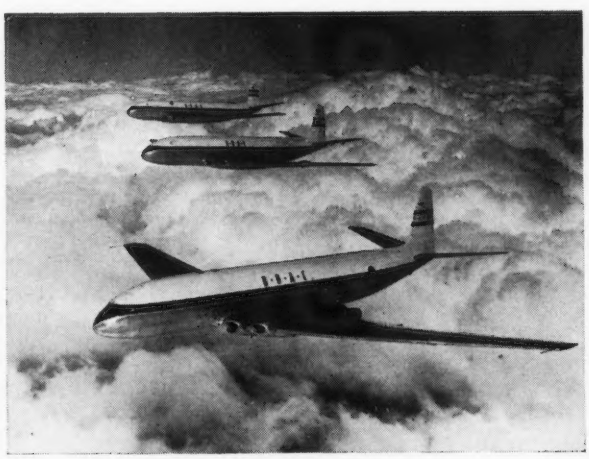


**Figure 1**
**Comet 1**

It may be interesting to compare the main capabilities of the Comet 1, Comet 2 and Comet 4.

The Comet 1 (Figure 1) was an aeroplane of 107,000 lb all-up-weight, with four de Havilland Ghost engines each of 5,000 lb thrust. It had an average practical stage length of about 1,500 nautical miles, including generous stand-off and alternate fuel allowances, and carried a payload of 11,000 lb.

**Figure 2**
**Comet 2**

The Comet 2 (Figure 2) has an all-up-weight of 120,000 lb and is fitted with four Rolls-Royce Avon engines of 7,000 lb thrust. It can carry a payload of 13,000 lb on a stage length of about 2,000 nautical miles. Figure 3 shows the Comet 3 which is similar in appearance to the Comet 4.

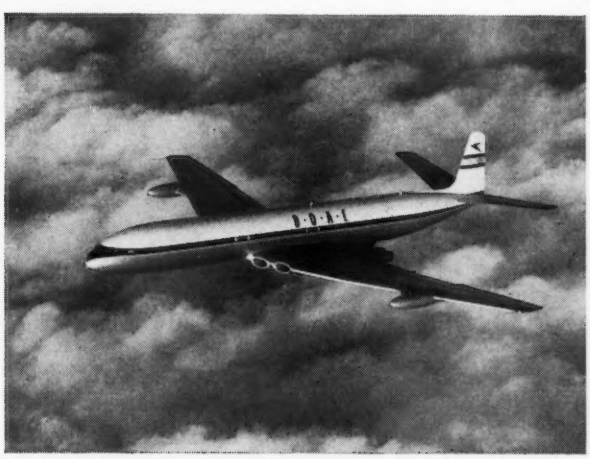


**Figure 3**
**Comet 3, the development aircraft for the Comet 4**

†Paper read at the Annual General Meeting of the C.A.I. in Montreal on May 4, 1956.
*Design Director.
**Chief Test Pilot.

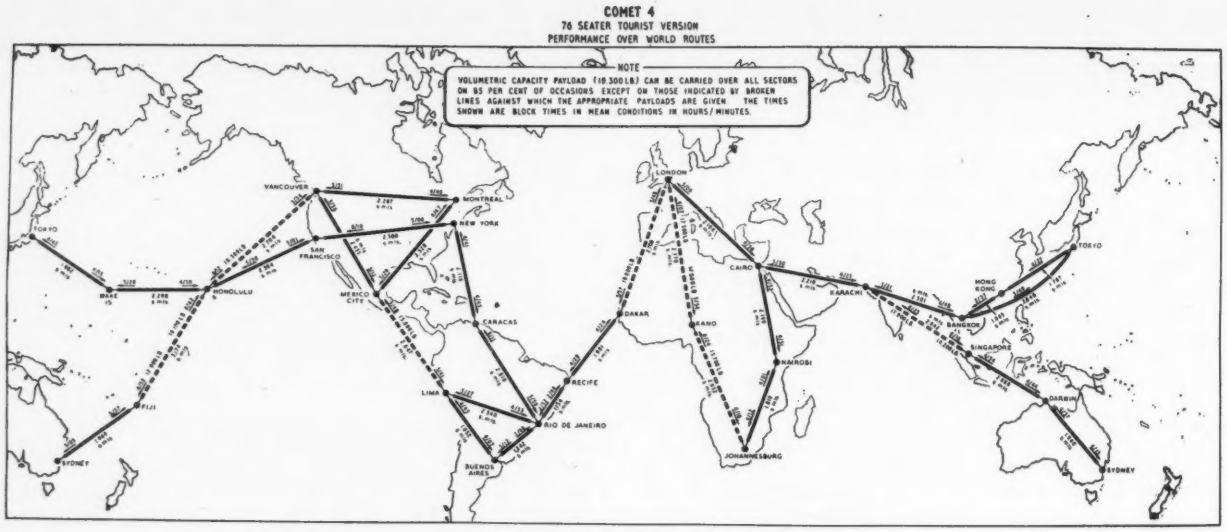



**Figure 5**
**Performance of the Comet 4 on representative stages of the world's air routes**

| | *COMET 1* | *COMET 2* | *COMET 4* |
|---|---|---|---|
| Maximum all-up-weight | 107,000 lb | 120,000 lb | 152,500 lb |
| Take off aerodrome length required at maximum all-up-weight at sea level. 30°C. | 8,680 ft | 6,570 ft | 7,170 ft. |
| Maximum stage length with comparable reserves and against a 50 mph headwind and first-class capacity payload of | 1,530 nm<br>10,200 lb | 2,065 nm<br>12,400 lb | 2,555 nm<br>16,700 lb |
| Landing aerodrome length required at sea level 30°C. with comparable reserves | 5,400 ft | 5,300 ft | 5,100 ft |
| Corresponding approach and stalling speeds | 108 kts<br>83 kts | 108 kts<br>85 kts | 122 kts<br>94 kts |

The Comet 4 will have an all-up-weight of 152,500 lb and has four Avon engines of 10,500 lb thrust. The capacity payload of the first-class version is 16,500 lb (60 passengers), and that of the tourist version, 19,300 lb (76 passengers). With these capacity payloads the stage lengths are approximately 2,600 nautical miles for the first-class version, and 2,350 nautical miles for the tourist version. In both cases they include full airline reserves and are based on a 45-knot headwind.

Figure 4 shows a comparison of the range-payload characteristics of the three types of Comet.

It should be noted that the stalling speed quoted for the Comet 4 is at maximum landing weight, a condition which caters for a diversion distance of approximately 1,150 nautical miles while carrying full capacity payload. A more normal landing weight with fuel for a diversion of 175 nautical miles would be 97,000 lb and at this weight the stalling speed is 86 knots.

## CAPABILITIES OF THE COMET 4

Examples of actual sectors over which the Comet 4 can carry its capacity payload of 76 tourist passengers (19,300 lb) are:

| | |
|---|---|
| New York – San Francisco | 2,240 nautical miles |
| Montreal – Vancouver | 1,985 nautical miles |
| Rio de Janeiro – Caracas | 2,440 nautical miles |
| Dakar – London | 2,350 nautical miles |
| Bangkok – Tokio | 2,525 nautical miles |

These sectors are shown in Figure 5 which summarizes the performance of the Comet 4 over a selection of the world trunk routes. Some of the sectors are just beyond the capacity-payload range but on most of these the payload limitation is not serious. In those cases where payload is severely limited, an intermediate point usually exists which can be used on those occasions when a high payload coincides with strong headwinds, for example, Canton on the Honolulu-Fiji sector. Take-off runway length does not limit the maximum permissible take-off weight or the payload, except at Lima where the runway is unusually short.

Taken all round the aerodrome performance of the Comet 4 is most impressive. On the recent world tour

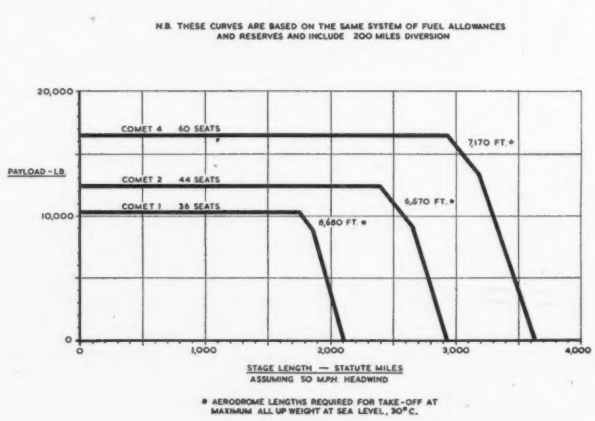



**Figure 4**
**Comparative payload — stage length**

of the Comet 3, airline pilots and airport officials alike were surprised at the short take-off and landing distances required and at the low landing speed. The stalling speed of 94 kts, quoted in the table above, is little higher than that of most propeller-driven aeroplanes in service today. Generally speaking the Comet 4 will be able to operate into and out of almost all important aerodromes as they exist now, without extension or runway strengthening.

The Comet 4 cruises above the weather at altitudes from 33,000 ft to 42,000 ft at around 500 mph (or about 435 knots). This gives a block speed of about 460 mph (or about 400 knots) on an average sector. A comparison of the block times of the Comet 4, shown on the map, with those achieved today by propeller-driven aircraft will show that in general the Comet 4 is able to halve the time on most routes. Thus, Sydney is brought within 27¼ hours of London; Montreal and Vancouver are only 5½ hours apart and the non-stop transcontinental flight from New York to San Francisco against the wind can be made in 6¼ hours; eastbound, the time is just over 5 hours.

**THE BEST SIZE OF AIRCRAFT**

When applied to a single route the very large jet transport is justified only if the route has a high traffic density, for example, the coast-to-coast route in the U.S.A. and across the North Atlantic.

A glance at the route maps of international airlines will show that only a very few sectors are more than 2,400 nautical miles long. The North Atlantic route and the polar routes of C.P.A. and S.A.S. are in a special category. On most other routes the bulk of the traffic is generated at intermediate points and only a part of it is end to end. These intermediate points will always have to be served and the range of an aircraft designed to operate over this type of network will be decided by the longest stage. Experience has shown that there are very few sectors in this type of network which are beyond the range of the Comet 4 and where an intermediate refuelling point is not available.

To serve the public, frequency and speed are both important and the medium-sized transport offers greater frequency for a given traffic volume. Furthermore existing airports throughout the world can be used without further lengthening or strengthening of runways or hard-standing. Government authorities will not *willingly* go to such further expense, particularly if there is available a suitable jet transport which will use their existing airports without alteration.

The medium-sized aircraft is easier to handle at airports. It can be refuelled and serviced more quickly. On international routes 60 passengers go through customs, health and immigration formalities in considerably less time than it takes to get 120 passengers through. For equal speed on international routes the time taken to the city centre of a passenger travelling in the medium-sized aircraft will be less or alternatively, if the larger aircraft has a high cruising speed, this advantage may largely be lost through the greater handling time.

Personal service to each individual passenger is an important attribute towards selling seats on an airline. If the aircraft becomes too large service becomes impersonal. Four-abreast seating is today a "must" for first-class travel. People on a long journey will not pay a first-class fare for the middle seat on a bench for three, unless it happens that a family of three or three friends are travelling together. The large jet transports provide for six-abreast tourist seating and to reduce this to four-abreast for first-class is uneconomical as it is highly wasteful of volumetric capacity.

The direct operating costs of the large aircraft are theoretically slightly better than those offered by the medium-sized vehicle. However, it is on the revenue side of the cost equation that the medium-sized jet transport scores over many sectors. An operator stands to gain or lose money relatively quickly with the jet transport (compared to today's aircraft), as the passenger load factor moves up or down from the break-even point, and it is obviously easier to obtain high payload factors with a medium-sized aircraft. However, the large jet has one advantage, which is that it becomes more economical in the tourist configuration when some degree of comfort is sacrificed, because the proportion of tourist seats to first-class that can be installed is greater than in the medium-sized aircraft. But before deciding on the large aircraft any operator must be certain that he can depend upon the volume of tourist traffic that the large aircraft offers. A minimum fleet of three aircraft operating at an annual utilization of 3,000 hours with a block speed of 435 knots and with 130 tourist seats offers 585 million tourist passenger-miles per year. Between New York and Miami this amounts to moving about 260,000 people annually in each direction. This is only a small proportion of the traffic on that route, but there are few routes in the world which will have that traffic density, even in the 1960's.

**STRUCTURAL DESIGN**

As soon as it had been established that pressure-cabin fatigue was the cause of the Comet 1 accidents and that compliance with a static load factor did not guarantee an adequate fatigue life, the following philosophy was adopted.

Thicker gauge materials would be used in the pressure cabin area and windows and cutouts would be redesigned so as to lower the stress level to such an extent that cracks would be most unlikely to occur during the life of the aircraft. Should however cracks occur due to damage in service, then the rate of propagation of the cracks would be so slow that they would readily be seen before they could possibly reach a dangerous magnitude.

The aim would be to demonstrate by suitable test specimens that no cracks would occur before a minimum of 60,000 reversals and that any cracks subsequently appearing would not propagate seriously before another 60,000 reversals. If each reversal is assumed to be equivalent to a 3 hour pressurized flight, the apparent life is 180,000 hours, but to this must be applied a scatter factor of six which gives a safe life of 30,000 hours. Another way of expressing this philosophy is to state that if an aircraft started life with a crack this would not become catastrophic within the commercial life of the aircraft as a factor of six would still be achieved before the crack would start to run quickly. To this end the following test programme was embarked upon.

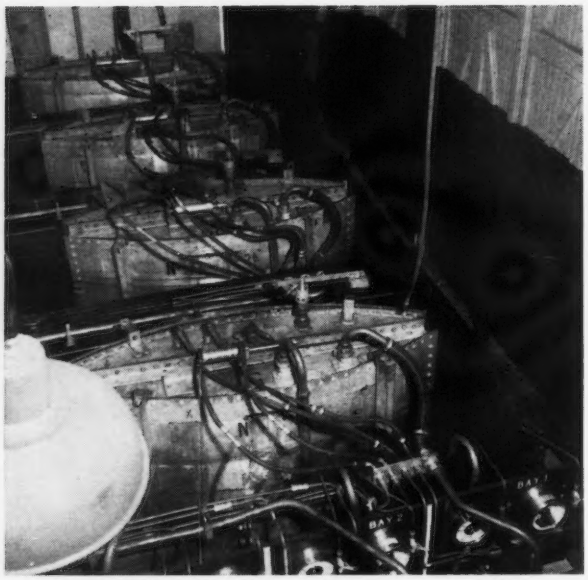


**Figure 6**
**Batch of Comet 4 fuselage cutouts under fatigue test at Hatfield**

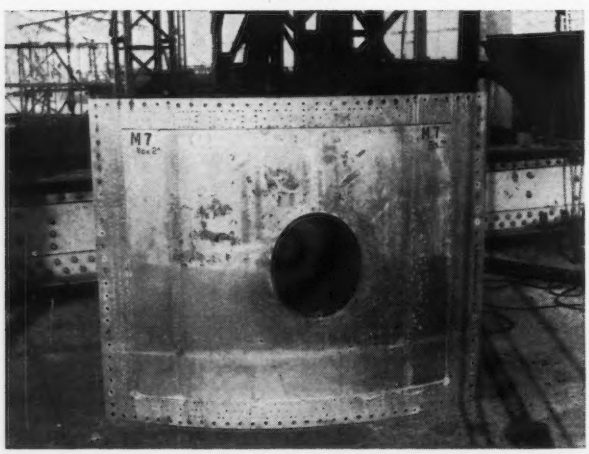



**Figure 7**
**Comet 4 window panel ready for fatigue pressure testing under water**

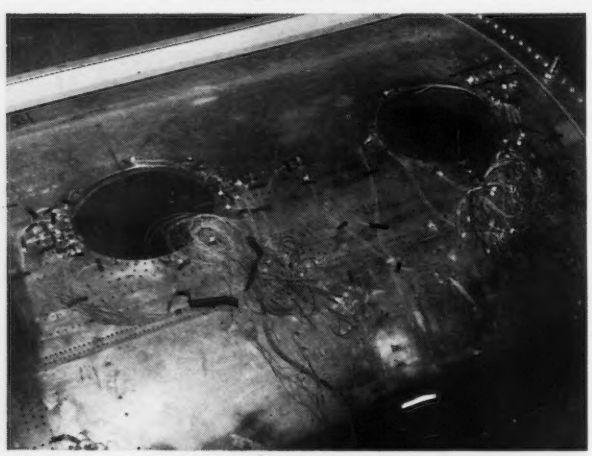


**Figure 8**
**Comet 4 window panel with strain gauges attached**

Six full-scale representative specimens of each main type of cutout were fatigue tested under water. Figure 6 shows a batch of specimens undergoing test, while Figure 7 shows one of these specimens. Typical of the results obtained from these tests is a panel in which cracks started at 68,000 reversals but did not propagate quickly until the figure of 164,000 reversals had been reached. Figure 8 shows a window panel undergoing strain gauge tests.

It is worth recording at this stage that in addition to the many specimens tested for proving the Comet 4, similar tests to establish design data, with particular reference to crack propagation, were carried out on some 30 Comet 1-type panels, mostly cut from actual fuselages to ensure that they were completely representative of production workmanship.

An important specimen in the series of tests was a 28 ft long fuselage section containing representative Comet 4 cutouts, comprising three cabin windows, an escape hatch, a passenger entry door, a freight door, an escape door, a luggage-bay door, two toilet drains and a de-icer pipe outlet. This specimen had up to the beginning of April completed 85,000 reversals of pressure, equivalent to 255,000 flying hours, without failure of any sort. Figure 9 shows this fuselage test section before being placed in position in one of our water tanks.

**Figure 9**
**Fuselage section containing representative Comet 4 cutouts**

A further 27 ft long test piece representative of the fuselage section has also been constructed and is now being tested in the water tank. In this test, in addition to internal pressure loads, the end load compression in the top flange of the front centre-section spar is also applied, thus including the effect of gust loads from the wing.

Figure 10 shows this specimen about to be placed in the tank, while Figure 11 shows a fatigue specimen representative of the canopy installed in the water tank.

The reason why we always test these large specimens under water with the specimen itself full of water is shown clearly in Figure 12. This is the result of an early test that we did during the design of the Comet 1 when a portion of the fuselage was tested to destruction with air pressure. It is at once obvious that the failure can be catastrophic and extremely dangerous and, at the same

**Figure 10**
**Comet 4 fuselage, centre section, before being placed in the water tank for fatigue testing**

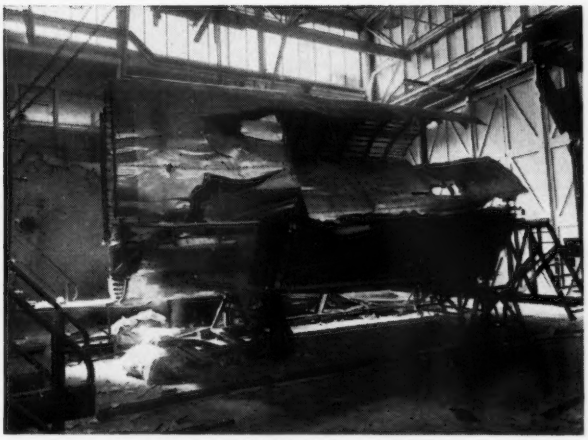


**Figure 12**
**Results of an early test using air pressure**

time, there is every chance that the evidence as to the cause of failure is lost since the whole specimen very nearly disintegrates.

Exhaustive testing has also been carried out on the wing spars and the main tension booms particularly have come under close investigation with a view to achieving adequate fatigue life. Similarly many tests have been conducted to ensure a satisfactory fatigue life for the skin on the bottom surface of the wing. In addition to these components many hundreds of tests have been carried out on examples of seam joints.

Figure 13 shows a wing spar undergoing fatigue testing and Figure 14 shows a centre-section spar after a fatigue test, whilst Figure 15 illustrates a portion of the bottom skin of the wing, incorporating an inspection hole after test.

It is confidently anticipated that the many thousands of tests, such as have been described, will establish beyond doubt the structural integrity of the Comet 4. The culmination of the test programme will consist of fatigue testing a complete Comet 4 in the water tank for the purpose of providing final confirmation of the design

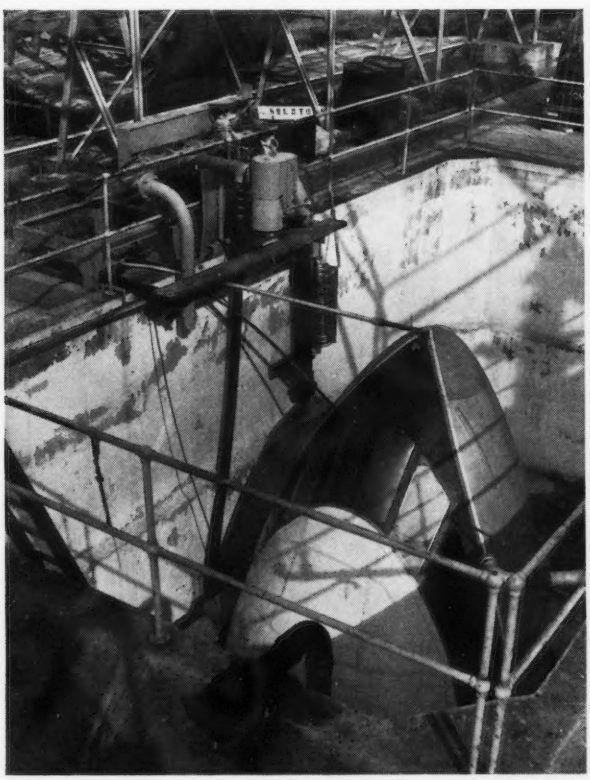


**Figure 11**
**Nose section of the Comet 4 in place in the water tank at Hatfield for fatigue pressure testing**

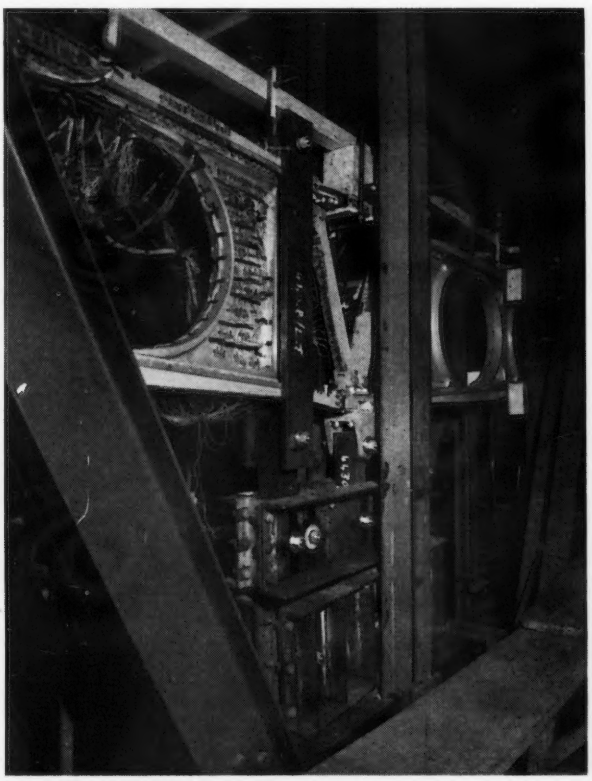


**Figure 13**
**Comet main spar in the structural test rig at Hatfield**

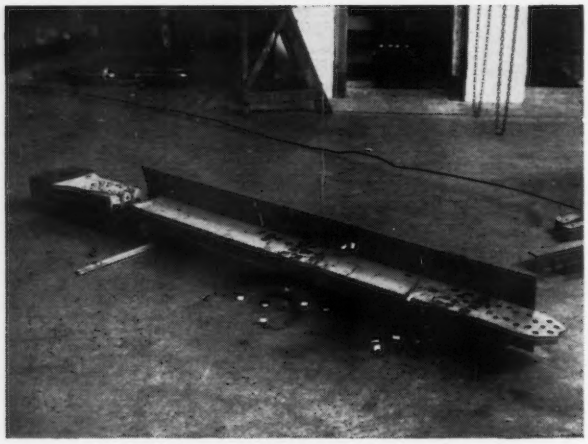


**Figure 14**
**A centre-section spar of the Comet 4 after fatigue testing to destruction**

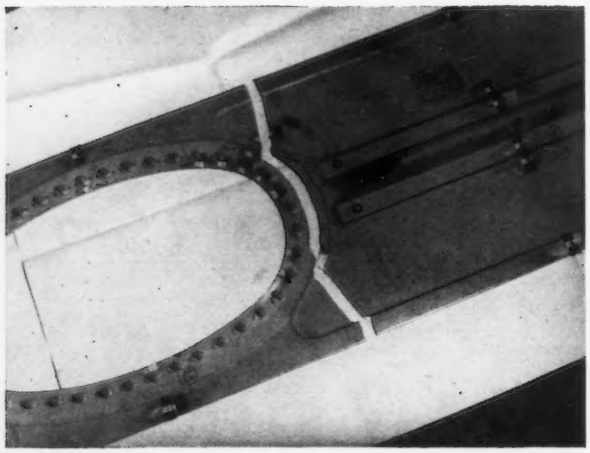


**Figure 15**
**Portion of the bottom skin of the Comet 4 wing, incorporating an inspection hole, after testing to destruction**

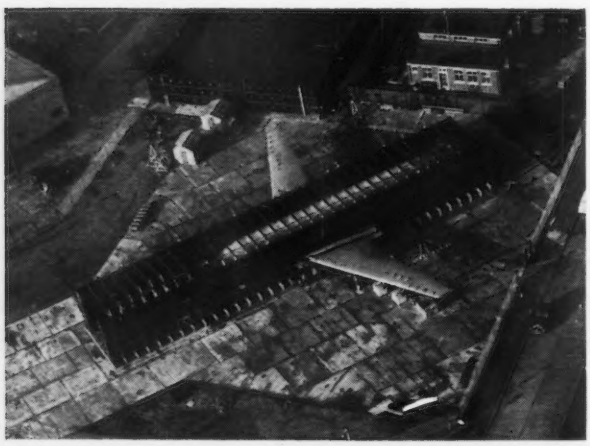


**Figure 16**
**The Comet pressure-testing water tank at Hatfield**

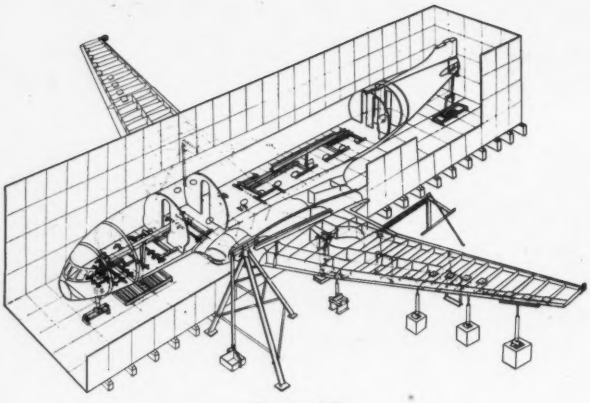


**Figure 17**
**The Comet water tank at Hatfield showing how the flight loads are applied to the structure of the aircraft**

philosophy. Figure 16 shows the Transport Command version of the Comet 2 undergoing similar tests in the water tank at Hatfield, while Figure 17 shows diagrammatically how the flight loads are applied to the structure of the aircraft in the water tank.

**ENGINE INSTALLATION**

A great deal has been said about the advantages of pod installations and it might therefore be of interest to consider some of the factors in favour of the wing installation as adopted for the Comet.

(1) In the wing installation, the height of the engine intake above ground is at a maximum and thus the risk of intake vortices sucking debris into the engine is reduced to a minimum. This is important, since any form of screen devised to prevent the entry of debris must be of relatively close mesh, and consequently the blockage effect is such that there is a prohibitive thrust loss amounting to 20 per cent or more of take-off power. Added to this is the certainty that if the screen were used in icing conditions, a complete blockage would occur, followed by an engine stoppage under the critical conditions of take-off.

It has been suggested that the wing-type intakes, being close inboard, are in a position where they may collect debris thrown up by the nose wheel. Experience to date has shown that the Comet is no more susceptible to engine damage from this cause than are other turbine-engined aircraft, but should the tests now scheduled on the Comet 3 show that this possibility exists, a simple remedy will be to put a guard around the nose wheel.

(2) Bringing the engines together and inboard has the following advantages:

(i) Shorter and simpler engine control runs.

(ii) The supply of air for cabin pressurization can be piped from the engine compressor with the minimum of piping and loss of heat.

(iii) Similarly, hot air from each engine compressor for wing and tail de-icing can be readily brought together into a common feed, thus ensuring continuity of feed to all surfaces in the case of one engine failing.

(iv) The engine mounting structure is reduced to the simplest possible form, because the engine is hung between ribs.

(3) From the maintenance aspect, the wing installation has other advantages. Access to the engines is excellent and work can proceed on the engine in the worst weather conditions under the protection of the wing and cowling doors. Figure 18, showing an Avon engine being installed in the Comet 3, illustrates this point.

(4) In the pod installation, where for drag reasons it is desirable to reduce the cowling size to a minimum, the ancillary equipment is necessarily closely packed, whereas in the case of the wing installation ample room for spacing equipment is available. This is an important factor where pipe joints, etc., have to be made, such as for instance the coupling of the engine intake to the rectifier for cooling purposes.

(5) There is no greater risk of a fire starting with the wing installation than there is with the pod installation, since in both cases the fuel and possible source of ignition are much the same. Whatever type of installation is used, it would seem equally desirable to put out a fire as rapidly as possible and the most important factor here is the ability to shut off the fuel to the engine. Furthermore, the close proximity of the engines allows the greatest possible advantage to be taken of the available fire extinguisher fluid and to bring the maximum quantity to bear on a particular seat of fire. Finally, the short and more simple control runs of the wing installation materially reduce the risk of a control failure.

(6) In a wheels-up landing the wing installation provides a high degree of protection for the engines since they are substantially protected by the spar structure and additionally, in the case of the Comet, by a strong superstructure built out from the spar to prevent the engine from coming into direct contact with the ground. This superstructure also carries a shear lever, which automatically operates the fire extinguishing sequence.

On the other hand, the pod installation must bear the full impact with the ground and while it may be argued that it would part from the wing, the resulting broken fuel and oil pipes and electrical wiring provide the conditions for starting a fire.

(7) If the wing fuel tanks are fractured in a crash landing, a serious fire hazard results from fuel being projected forward and then being sucked into the engine intake. In the case of the Comet no fuel is carried above or behind the engines and therefore this hazard is reduced to a minimum.

The pod installation, on the other hand, offers the greatest hazard from this cause, since fuel may be both above and behind the engine, and the engine striking the ground may itself be the cause of the fuel tank rupture.

(8) The wing-type engine installation has in the past been particularly criticized for its vulnerability to turbine blade or disc failure. In conjunction with blade development, devised to prevent blade failure, effective means of containing a failed blade have now been developed and incorporated in Avon engines. In the case of a disc failure the released energy could have equally severe consequences in either a wing or a pod installation. As far as blade failure is concerned, the record to date of British turbine engines is remarkably good. The possibility of a turbine disc failure is likewise extremely remote and is in the same category as that of a catastrophic propeller blade failure on a piston-engined aeroplane.

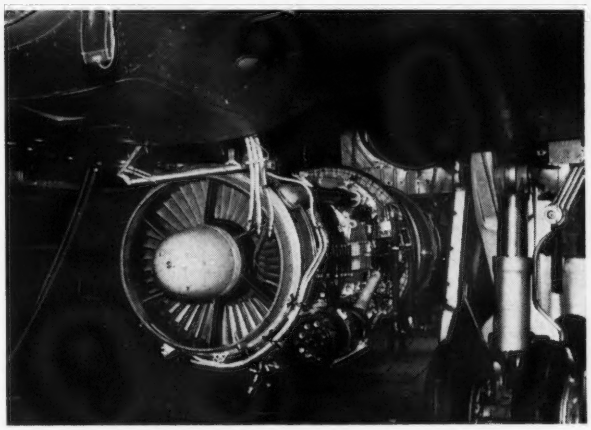


**Figure 18**
**Avon engine being installed in the Comet 3 aircraft**

(9) The close grouping of the engines as in the Comet, has enabled a simple fuel-feed system to be devised, because all the wing fuel can be brought to a common location; the complications of feeding inboard fuel to outboard engine and vice versa do not arise and all the fuel is available to the engines without a complicated system of cock operation.

(10) Perhaps the biggest advantage of the buried-engine installation is the fact that the engines are close to the centre line of the aircraft and that the old problem of asymmetric thrust has been almost completely done away with. An outboard engine can be cut on take-off literally without the pilot being aware of the fact. This to us would seem to be a very great advantage which should not be lightly thrown away. While it is of course possible to cope with the large asymmetric thrust from engines half-way out on the wing span, it does involve a quick reaction on the part of the pilot and considerable weight must be put into the aeroplane structure in the shape of large fins and rudders, and in the strengthening of the rear fuselage to deal with the rudder loads needed to keep the aircraft straight.

**CONTROL SYSTEM**

During the design of the Comet control system it was considered that any secondary stand-by system should be at least comparable with the primary system as regards effectiveness and pilot's effort required at all speeds and mach numbers at which the aeroplane would fly. In other words a very heavy and ineffective secondary system was not good enough. For this reason it was thought better to concentrate on a purely power system, with really adequate duplication and safeguards against failure, than to rely on a power system with a stand-by manual-reversion system of doubtful quality.

In a well-designed power control system with proper duplication of hydraulic boosters and control valves, loss of hydraulic fluid is by far the greatest risk. For this reason the Comet 4 will have three completely separate hydraulic systems, not inter-connected in any way, each of which is capable of operating the flying controls.

It is worth remembering that such dangers as runaway power-control valves, seized valves, a seized ram in the booster, or a mechanical failure of any sort in the control circuit and booster mechanism, are all common to the pure power-control system and to the power-control system with manual reversion. The latter system is no better off in the event of failure of any of these units than is the purely power-operated system. In this connection it should be remembered that every DC-3 with an automatic pilot has the hydraulic rams of the autopilot inserted in the main control run. Experience of other aeroplanes with power controls over the last few years has shown the great danger of runaway electrical trimming devices on tail plane or aileron and a number of accidents, particularly to military aircraft, have been caused by the undue complication resulting from attempts to provide for manual reversion in the event of failure of the power system.

We believe very strongly that provided really adequate safeguards are taken against loss of hydraulic fluid and that boosters and other valves are duplicated, it is far better to have a simple power system without the very considerable complication which inevitably results from the attempt to combine power controls with manual reversion.

During the last six years considerable development has gone into the Comet controls. The Comet 4 will have a change-gear device on the elevator system to give lower elevator-to-stick gearing for all flying except in the circuit and during take-off and landing. "Q" feel is being incorporated in the elevator controls and consequently the control feel has been considerably improved.

**DETAIL DESIGN DEVELOPMENT**

Since the first Comet flew in 1949 a continuous programme of detail design improvements, based on the results of tests and on the great accumulation of practical experience, has been carried out. In addition to the major changes already described the following are some of the more important improvements incorporated in the Comet 4:

(1) A change of wing section, eliminating the possibility of a ground stall. (Figure 19)

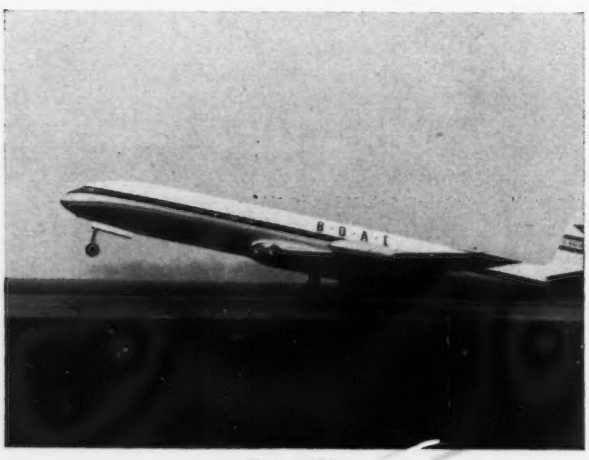



**Figure 19**
**Comet 3 taking off from Hatfield with the tail bumper in contact with the runway**

(2) Greatly increased flap area with the ability to provide an increase in drag during the final stages of the approach.

(3) The hydraulic equipment in the fuselage has now been located in an entirely separate equipment bay remote from any electrical equipment.

(4) Considerable development work and a great deal of testing has been devoted to improving the flameproof properties of all items of electrical equipment.

(5) Fuel heaters and integrating flow-meters are provided in the fuel system and a turbine blade shroud has been incorporated in the engine which is capable of containing a turbine blade in the very unlikely event of a turbine blade failure.

(6) A great deal of development work has gone into improving the ventilation and the fire prevention and detection systems in the engine zones. The Comet 4 engine installation is scheduled to be tested in the Rolls-Royce fire tunnel at Hucknall.

(7) Dunlop Maxaret anti-skid brakes are fitted and provision is made for a tail parachute; meanwhile reverse thrust is under active development on the Comet 2 and will be fitted on the Comet 4 as soon as a satisfactory system has been developed.

(8) Considerable development work is being done to reduce jet noise. A Greatrex corrugated type of jet nozzle is being tested and appears to offer the possibility of a worthwhile reduction of noise, although it must be pointed out that the Comet 4 with its more moderately powered engines is not in such great need of noise reduction as are its more powerful competitors.

(9) The Flight Deck has been largely re-designed to provide for five crew stations, which allows for flexibility in crew composition or for supernumerary crew members for training purposes.

(10) Full provision is made for automatic blind approach and the latest version of Smith Auto Pilot SEP.2A, with provision for height and A.S.I. lock, is fitted; also there is provision for cloud warning search radar.

(11) Alternative cabin arrangements have been devised to accommodate either all first-class passengers, mixed first and tourist class or all tourist class. The cabin is readily convertible to any of these configurations simply by changing passenger seats which are mounted on rails to provide variation of seat pitch. An additional door-type emergency exit is provided at the rear of the main cabin on the starboard side.

**COMET FLYING EXPERIENCE**

The Comet first flew in July, 1949, and exactly one year later in July, 1950, the second prototype flew, by which time some 360 hours development flying had been achieved on the original aircraft.

Further development flying with both aircraft continued and in March, 1951, three B.O.A.C. pilots were trained to fly on the second prototype Comet which

was then given a Certificate of Airworthiness for route-proving trials.

For six months, during which time B.O.A.C. flew about 500 hours, the second prototype flew repeatedly over the South African and Indian routes to enable B.O.A.C. to find out how to operate a turbojet and how to work the Comet into the existing facilities and airways systems.

On the whole, very few major problems arose and B.O.A.C. satisfied themselves that the matter of operating the aircraft on a cruise-climb technique was entirely practical, that holding in a stack was no different from piston-engined aircraft procedures and that no change was necessary in the landing weather minima used for the rest of the Corporation's fleet, such as for instance the London Airport figures of 300 ft cloud and 500 yds visibility.

Valuable experience was gained in deciding how to enable rapid transit stops to be achieved because, due to the Comet 1's relatively short stage lengths, time spent in refuelling on the ground had to be cut to a minimum.

All this preliminary operating experience enabled B.O.A.C. to start their passenger carrying service on the route between London and South Africa in May, 1952—that was just 2¾ years after the first flight of the Comet.

It is of interest to note that the Comet had no special treatment from control authorities wherever it operated. The only change from normal procedure was that the pilot was given clearance to start engines on the understanding that within five minutes of that time the aircraft would be ready to move off to the duty runway for an immediate take-off.

Because the turbine transport has so much passenger appeal compared to the piston-engined aeroplane, B.O.A.C. had very high load factors—in the order of 80 per cent—on the Comet 1. This made it possible for B.O.A.C. to make a profit on their Comet operations but it was abundantly clear that a lower break-even load factor than that of the Comet 1 was necessary for future jets.

All Comets in service up to the time they were grounded were equipped with de Havilland Ghost engines fitted with centrifugal impellers and giving 5,000 lb of thrust, but early in 1952, as a preliminary to producing the Comet 2, we flew a modified Comet 1 fitted with axial-compressor Rolls-Royce Avon engines giving 7,000 lb of thrust.

During a period of nearly two years of airline service, Comets amassed a total of just over 30,000 hours flying and from this experience it is clearly possible to answer a number of the controversial questions still being discussed to-day.

Firstly there is absolutely no doubt that passengers prefer jets; apart from the occasional inter-tropical front, turbulence at cruising heights between 35,000 and 40,000 feet is a rarity. The occasions on which clear air turbulence or turbulence due to the presence of a jet stream have been met are very few and even then the turbulence has been mild. The rapid rate of climb and descent of the jet airliner means that passengers spend less time in turbulence at the lower levels. But perhaps the most important factor in passenger appeal is the smoothness of the pure jet which has to be experienced to be believed. Incidentally because of this general lack of vibration in the aircraft, the instruments and the radio equipment gave very good service.

From the mechanical point of view the Ghost engine overhaul life had reached 750 hours within two years of being first used in airline service and already it was clear that they were much less liable to random failure en route or on take-off than contemporary piston engines.

We did find it necessary to watch the effect of the shock waves from the turbine tail pipe blast at take-off power on some panels in the rear fuselage and on the tail plane. This area behind the jet pipes has to be able to stand a considerable amount of noise and vibration during the take-off run while the aircraft is still on the ground.

It is interesting to recall that, throughout the two years of operations over many routes, the noise of the Comet at airports was never any real problem. Normal use was made of the apron for loading and unloading passengers and there was no need to tow aircraft to the end of the runway before starting engines as many people had suggested. The short time needed for a turbine-engined aircraft to complete a "before take-off" cockpit check helped considerably in reducing time wasted on the ground after loading passengers.

Underwing pressure refuelling also helped to make rapid transit times possible. The normal time spent on the ground was 40 minutes, although I believe the minimum time of 25 minutes—wheels on the ground to wheels off—for a transit at Khartoum was the fastest achieved by B.O.A.C. This time compared well with piston-engined aircraft being operated over the same route.

Although the Comet 3 is not going into production, it does incorporate a great deal of what we have learned to be necessary from hard flying experience on Comet aircraft for the last 6½ years. It was with the idea of proving to ourselves that we had benefited from this hard-won experience that we decided, as part of our development flying programme for the Comet 4, to undertake a flight to Australia returning to the United Kingdom across the Pacific and Canada and using the aeroplane in exactly the same way as we intend it to be used when in airline service. We naturally took the opportunity to give interested operators first-hand experience of jet transport flying and in all we took some 500 people into the air on demonstration flights.

With many people turning their thoughts to the problems involved in flying jet transports over world routes it is interesting to note that throughout our round-the-world trip we made use of existing airfields, the standard navigational aids and the normal meteorological facilities and found them all very satisfactory. The radio facilities throughout the world were adequate with one exception. The exception was the lack of D.M.E. or Distance Measuring Equipment on the ground. To enable a jet to commence its descent from cruising height it is vital to know your exact distance from your destination. Descent is normally started when 180 nautical miles from the landing point. The H.F. R/T worked well as did our V.H.F. and Loran where coverage was available.

The meteorological forecasts for upper air winds were very accurate throughout our journey and it is worth noting that the flight time, as taken from the

COMET 3 G-ANLO LONG RANGE FLIGHT PLAN

FROM HONOLULU TO VANCOUVER ALTERNATE ABBOTSFORD DIST. 33 N.M. E.T.D. 16·00 HRS. DATE 16-12-55

| FROM | TO | CLIMB CRUISE DESCENT | TEMP DEV. TO STD °C | GREAT C.A.S. KTS. | TRUE TRACK | WIND DIRN. | WIND SPEED KTS. | WIND COMP. KTS. | DRIFT | EST. G.S. KTS. | DISTANCE – N.M. GROUND | DISTANCE – N.M. AIR | EST. ELAPSED TIME HRS. | PLANNED FUEL KG. INCREMENT | PLANNED FUEL KG. TOT. USED AT END OF SECTOR | E.T.A. HRS. – REM. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HONOLULU | T.O.C. | CLIMB | +10 | 325 | 044 | 340 | 10 | -2 | -1 | 323 | 185 | 185 | 32 | 3,525 | 3,525 | 16-32 |
| T.O.C. | 150°W | CRUISE | +3 | 426 | 044 | 240 | 30 | +28 | -2 | 454 | 425 | 397 | 56 | 3,670 | 7,195 | 17-28 |
| 150°W | 145°W | ~~~ | STD. | 421 | 044 | 235 | 50 | +46 | -2 | 467 | 373 | 340 | 48 | 3,050 | 10,245 | 18-16 |
| 145°W | 140°W | ~~~ | ~~~ | 419 | 044 | 250 | 65 | +55 | -5 | 474 | 354 | 320 | 45 | 2,850 | 13,095 | 19-01 |
| 140°W | 135°W | ~~~ | ~~~ | 416 | 044 | 270 | 50 | +31 | -6 | 447 | 338 | 315 | 45 | 2,600 | 15,695 | 19-46 |
| 135°W | 130°W | ~~~ | ~~~ | 415 | 044 | 240 | 25 | +19 | -1 | 434 | 321 | 305 | 44 | 2,300 | 17,995 | 20-30 |
| 130°W | T.O.D. | ~~~ | +3 | 415 | 044 | 290 | 25 | +9 | -3 | 424 | 232 | 215 | 33 | 1,700 | 19,695 | 21-03 |
| T.O.D. | O/H VANCOUVER | DESCENT | -2 | 325 | 044 | 060 | 15 | -15 | 0 | 310 | 180 | 200 | 34 | 920 | 20,615 | 21-37 |
| | | | | | RETURN | TO | | HONOLULU | FROM | RET. | | | | | | |
| O/H HONOLULU | T.O.D. | DESCENT | -2 | 325 | | | | +2 | | | 180 | 180 | | 920 | 920 | |
| T.O.D. | 150°W | CRUISE | +3 | 416 | | | | -30 | | | 430 | 465 | | 3,395 | 4,315 | |
| 150°W | 145°W | ~~~ | STD | 415 | | | | -49 | | | 373 | 425 | | 3,500 | 7,765 | |
| 145°W | 140°W | ~~~ | STD | 418 | | | | -58 | | | 354 | 410 | | 3,550 | 11,315 | |

| TOTAL DISTANCE | TOT. TIME HRS-MIN | TOTAL FUEL |
|---|---|---|
| 2,408 | 2287 | 5-37 | 20,615 |

| | | | |
|---|---|---|---|
| DRY WEIGHT | 34,500 KG. | ARRIVAL WT. O.H. | 42,685 KG. |
| FUEL WEIGHT | 29,200 KG. | 5% ALLOWANCE | 1,000 KG. |
| A.U.W. | 63,700 KG. | APPROACH FUEL | 500 KG. |
| PRE. T.O. FUEL | 400 KG. | LANDING WEIGHT | 42,185 KG. |
| T.O.W. | 63,300 KG. | RESERVE FUEL | 6,685 KG. |
| STAGE FUEL | 20,615 KG. | DIVERSION FUEL | 500 KG. |

**Figure 20**
**Example of a Flight Plan used on the Comet 3 world flight in December 1955**

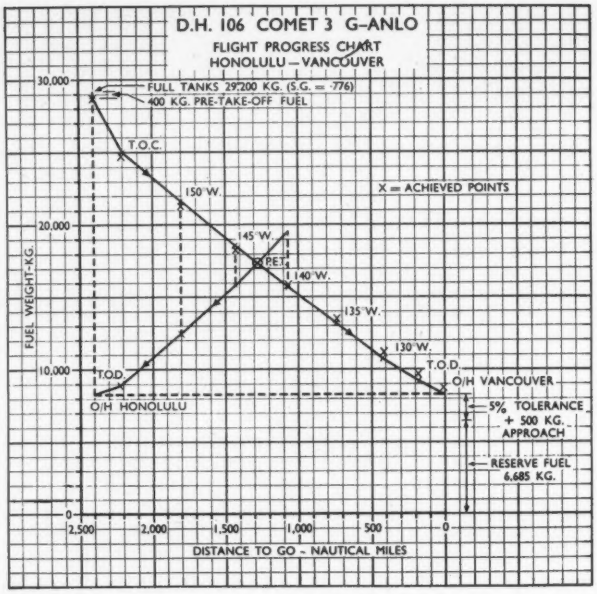



**Figure 21**
**Flight Progress Chart of the Comet 3 world flight**

Comet 4 brochure printed four months before our departure for Sydney in the Comet 3, gave a flight time of 24 hours 30 minutes against the 50 per cent wind. The actual flight time for this flight was 24 hours 25 minutes.

An example of a Flight Plan together with a Flight Progress Chart or "Howgozit" of the Honolulu to Vancouver sector of our flight (Figures 20 and 21) show clearly the way a flight plan is made and how our distance flown and fuel used are plotted in an easily readable way.

Variations in forecast wind speeds have to be pretty big to have much effect on the flight time achieved and, in fact, on this leg of 2,408 nautical miles, the actual flight time was 5 hours 40 minutes—that is 3 minutes longer than the flight-plan time.

To return to the mechanical side of the Comet 3, we use electric starters on our engines and the aircraft battery system is fully capable of starting all engines when there is no suitable ground power unit available, so apart from the provision of kerosene or J.P.1 we do not require anything out of the ordinary in ground equipment. Runway lengths and strengths are more than adequate on all the major airfields and, much to many people's surprise, the noise problem on the Comet 3 is not really very serious.

One reason for this is that an aircraft with a low wing loading and a power/weight ratio of the order of 4 to 1, or even slightly better, has a high degree of acceleration and a quick unstick. On all take-offs the power is reduced to the cruise-power setting, which we use for climb up to 30,000 feet altitude, by the time the end of the runway has been crossed. The high rate of climb at the reduced power setting makes the Comet 3 a relatively quiet aircraft in the vicinity of an airfield. Naturally we hope for improvement by fitting the corrugated nozzle now being developed by Rolls-Royce. Incidentally the fitting of the corrugated nozzle does not prevent the use of a thrust reverser for landing.

While welcoming the idea of reverse thrust there will no doubt be some price to pay in efficiency and in extra weight and I have no doubt at all that the Comet 4 can be operated perfectly satisfactorily without thrust reversers. The low landing speed coupled with very powerful wheel brakes fitted with anti-skid devices gives a very short stopping distance under all runway conditions. If it is said that it is not possible to rely on wheel brakes on icy runways, how is it that North Stars manage to operate continuously without braking propellers on icy runways? Nevertheless we are just about to fly an experimental reverse thrust installation on a Comet and are keen to find out what the problems are.

To sum up our general experience since 1949 I can say that Comet flying was much enjoyed by all aircrew and cabin attendants but it was naturally noticed by all aircrew that, although they were flying in the greatest comfort and smoothness, they had to think rather further ahead in distance than they had been used to on the slower aircraft and this feature, of course, will be present on all jet transports.

Perhaps the feature most remarked on by pilots when converting from propeller transports to a Comet 1 was the apparent lack of deceleration when closing the throttles during the landing. This feature is present in most jet aircraft flying to-day but has been largely overcome by the provision of enormous wing flaps on the Comet 3. Similar flaps will also be a feature of the Comet 4.

The flying time required to convert pilots from piston-engined transports to the Comet 1 was no longer than that required to convert to another piston-engined type. So far as flying and handling are concerned the Comet presented no big problem. The most important difference that must be impressed on the jet transport pilot is that you have to stay up high to achieve your desired range and any decision to divert due to bad weather at your terminal must be taken quickly.

Perhaps the only penalty for flying fast in a smooth aircraft is that the pilot's mind must work rather more quickly than it may have had to in the past.

# C.A.I. LOG

## SECRETARY'S LETTER

### ANNUAL GENERAL MEETING

For reasons of hotel accommodation and other considerations, the Annual General Meeting of the Institute, the end of the Institute's year, was held early in May and in many cases preceded the Annual General Meetings of the Branches. This was perhaps rather unfortunate but the Branches skilfully held their elections a little early to enable the new Council to take office at the appointed time.

#### Meeting

The Annual General Meeting is reported fully elsewhere and I will not dwell on it now, except to draw attention to the value of these functions as "get-togethers". By means of these meetings, the Institute is providing a common ground for all the technical people in Canadian aviation. Quite apart from the strictly technical side of the thing, there is a great deal of benefit to be derived from meeting people from other companies, from other parts of Canada and from other fields of aeronautical work. The Dinners and Receptions and milling about the Registration Desk are by no means the least valuable parts of these affairs.

For my own part this aspect of our meetings is almost embarrassing. In Montreal I kept meeting people whom I had not seen for ages and many others introduced themselves and said a few words. In the general turbulence I was quite unable to talk to them as I should have liked to have done; I am afraid that at times I must have appeared positively rude and I hope that, in the circumstances, I will be forgiven.

#### Business Session

It was very gratifying to note the good attendance at the Business Session. This Session was held first thing in the morning on the first day of the Meeting and it might well have been "passed up" in favour of the attractions of a late breakfast and the technical Sessions which followed. But a goodly number were there shortly after 9 o'clock.

Such attendance is a reflection of the vitality of the Institute. It is important that members should take an interest in the way the Institute works and it is an unhealthy state of affairs when members "let George do it" so long as George delivers the goods. The more people who consider themselves to have a hand in the running of the Institute, the better the Institute will be run, to the benefit of all of us.

### UPGRADING

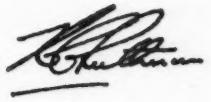
Last month I wrote about grading, addressing my remarks primarily to those who, for one reason or another, were dissatisfied with the grades to which they were originally admitted. For the benefit of those who, though tolerably happy about their original grading, feel that they now qualify for higher grades, I should have explained that no one can be upgraded (except to the grade of Fellow) unless he applies for it. I understand that there is an impression in some quarters that, as each Technical Member passes the 8 year mark, our records automatically show it and his case is brought forward, as a matter of course, for consideration by the Admissions Committee and the Council. This is not so. If a member wants to be upgraded, he must apply.

### LIST OF MEMBERS

To initiate our summer job, we have recently sent out cards again in connection with a re-issue of the List of Members. Members are asked to complete them and return them to Headquarters as promptly as possible. It is very difficult to prepare the List satisfactorily if we do not have up-to-date information on each member, submitted by the member himself.

### NEXT ISSUE

This is the last issue of the Journal for a couple of months; the next issue will appear in September, when I hope we will be all set for another active season. In the meantime, enjoy your holidays.



# ANNUAL GENERAL MEETING

THE Annual General Meeting of the Institute was held in the Sheraton-Mount Royal Hotel, Montreal, on the 3rd and 4th May. The programme opened with a Business Session, followed by morning and afternoon technical sessions, and a Dinner in the evening of the first day; on the second day one technical session was held in the morning and two, concurrently, in the afternoon. The registration amounted to 498.

**BUSINESS SESSION**

The Business Session took place in the Sheraton Hall, attended by over 80 members. Mr. R. J. Conrath, Vice-Chairman of the Montreal Branch, welcomed the members attending the meeting and then handed the proceedings over to the President. After a few introductory remarks, the President read the Annual Report of the Council, which was followed by the presentation of the Reports of the Publications, Admissions, Finance, Programmes and Education and Training Committees, read by their respective Chairmen. (These Reports are reproduced on pages 215 to 223 of this issue of the Journal.) The session closed with a brief discussion from the floor.

**THE DINNER**

The programme of the Dinner, at which 630 members and guests were present, was presided over by Mr. R. D. Richmond, the retiring President of the C.A.I. He opened the proceedings with a Toast to Her Majesty the Queen and the introduction of the Head Table. In a brief address he gave a resumé of the year's activities, making special reference to the advice and cooperation extended by the Royal Aeronautical Society and the Institute of the Aeronautical Sciences and he read the following telegram received on this occasion from the President of the I.A.S.

"On the occasion of this Third Annual General Meeting of the C.A.I. congratulations are extended by your sister society, the Institute of the Aeronautical Sciences, for two successful years in our field of endeavour. Sincerely regret inability to attend meeting and dinner. Please convey to all my greetings and good wishes for the third year now commencing.

EDWARD R. SHARPE"

*Gazette Photo*

**A/V/M M. M. Hendrick**
**Principal Speaker**

The President then briefly touched on the plans under consideration for the coming year, including the establishment of an award for the best paper presented to the Institute, a proposal to develop services for members engaged in certain specialist fields, and the holding of at least one Council meeting during the year at one of the western Branches.

At the conclusion of his address, the President announced the award of Honorary Fellowship to

Air Marshal W. A. Curtis

Air Marshal Curtis was present and was able to accept his Certificate from the President's hands.

*Gazette Photo*

**A/M W. A. Curtis acknowledging his appointment as an Honorary Fellow.**

Before introducing the Principal Speaker, Mr. Richmond suggested that a message of greeting should be sent to His Royal Highness the Duke of Edinburgh, as follows:

"Your Royal Highness

The Canadian Aeronautical Institute is now holding in Montreal its first Annual General Meeting since Your Royal Highness graciously consented to become its Patron. On this occasion, we, the Members of the Institute, wish to express again our pleasure at Your Royal Highness' interest in our proceedings."

The address of the Principal Speaker, Air Vice-Marshal M. M. Hendrick, Air Member for Technical Services, R.C.A.F., is reproduced in full on another page. At its conclusion, Mr. I. A. Gray, Chairman of the Vancouver Branch, thanked the Speaker on behalf of the Institute, making the point that, while many of those present were familiar with limited aspects of the Air Force, few had previously enjoyed so complete a summary of its broad technical scope.

The final item on the programme was the presentation of the McCurdy Award for 1955 to Mr. J. H. Parkin. The citation was read by the President and the presentation was made by the Hon. J. A. D. McCurdy himself.

The proceedings concluded with the President introducing his successor in office, Mr. T. E. Stephenson, and transferring the President's Badge to him. The new President thanked Mr. Richmond and paid warm tribute to the Chairman and Executive Committee of the Montreal Branch for their hospitality and for their work in arranging such a successful meeting; he then declared the Dinner adjourned.

**TECHNICAL SESSIONS**

The technical sessions have been reported by members of the Institute, as follows:

**Morning Session May 3rd**

**Propulsion**

Reported by P. B. Clay

This was the first technical session of the Annual General Meeting, following on a successful Business Meeting, and was well attended.

*Gazette Photo*

**Mr. T. E. Stephenson, President for 1956-57, receiving the President's Badge from Mr. R. D. Richmond, retiring President. On the right is the Hon. J. A. D. McCurdy.**

The Chairman for the session was Dr. D. L. Mordell of McGill University and the first paper, entitled "The Development of Rolls-Royce Propeller Turbine Engines", was presented by Mr. D. Huddie, Chief Development Engineer for Civil Engines, Rolls-Royce Limited.

Mr. Huddie briefly traced the history of the propeller turbine engine as developed by his Company, outlining the advances made in respect of reliability, performance and control systems, with some brief reference to development costs, starting with the "Trent" engine of 1943 up to the "Dart" and "Tyne" engines of today, the latter developing some 4,470 tehp at take-off conditions with considerable ability for future development.

Leaving the truly technical aspects of the paper, Mr. Huddie explained the design - development concept of the Company, pointing out how experience gained and, in a number of cases, an actual component utilized, on one engine, suitably scaled, was incorporated in other engines. Considerable advantages, it would appear, are to be gained from this policy in the way of full scale test and service experience with obvious advantages in reliability and life expectancy.

A point outlined with care was the way in which flight development and actual airline service experience was obtained on the Dart engine. Initial flight development was carried out with a Dart engine installed in the nose of a Lancastrian aircraft, while airline experience was accumulated with two Dart Dakotas which, after being given a Certificate of Airworthiness, went into scheduled airline operation as freighters. This method of flight development, important since the engines concerned are probably the first to enter passenger carrying service with no background of military operation, is to be used with the Rolls-Royce Tyne engine, using a four-engined Lincoln and twin-engined Ambassadors.

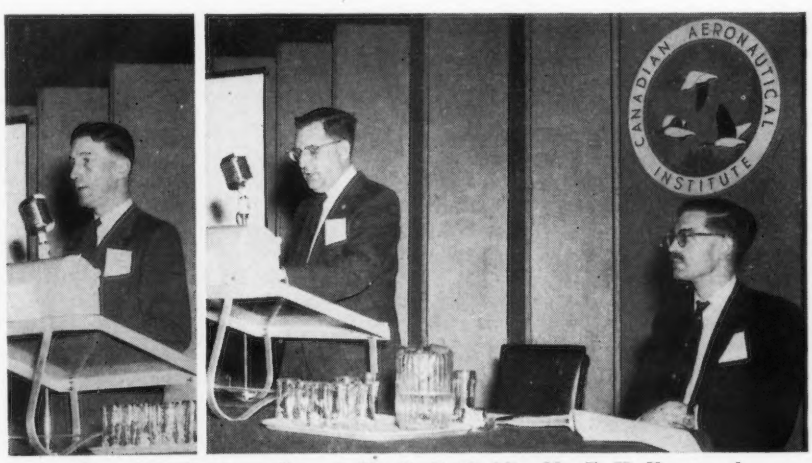
The second and last paper of the session was presented by Mr. F. H. Keast, Deputy Chief Engineer, Orenda Engines Limited, entitled "Choice of Design for an Advanced Turbojet".

This paper centred around the propulsive means for a supersonic fighter and one gained the impression that this was certainly a very large engine having a rating of the order of 20,000 lb static thrust with even more available as a result of afterburning although, in view of certain design considerations, the increase in power with afterburning may not be so great as might be expected.

Even with the widespread use of new techniques and materials, such as resin bonded fibre glass compressor rotor blades for low speed flight engines, titanium discs and fabricated casings, it seems obvious that the weight of the hypothetical engine was also considerably in excess of current large engines. An example of the advantages to be gained from the use of titanium, weightwise, was given, citing a turbine disc and blade assembly; using steel the weight was given as 77 lb against 33 lb in titanium, a saving of 57% which, in addition to a straight saving in weight, has a number of other advantages.

A most interesting and major part of the paper was that dealing with the number of variations and combinations available, dependent upon the requirements and role of the aircraft for which the engine is intended and, as concluded by Mr. Keast, the use of a twin spool engine as a basis of design is most advantageous if it is intended that variations of that engine shall be used for different applications.

Question and discussion time at this session was disappointing, particularly so since the Chairman had steered the session so as to leave ample time for what was anticipated to be a busy period, unless one considers that this was the result of the clarity of the papers and their excellent presentation.




**Propulsion Session: (l to r) Mr. D. P. Huddie, Mr. F. H. Keast and Prof. D. L. Mordell (Chairman).**

**Manufacturing Session: (l to r) Mr. L. B. Gray, Mr. H. F. Young, Mr. H. L. McKeown and Mr. R. B. McIntyre (Chairman).**

**Afternoon Session May 3rd**
**Manufacturing**

Reported by J. J. Waller, W. B. Boggs and C. L. Bernier

The Chairman of this session was Mr. R. B. McIntyre, Assistant General Manager of Dowty Equipment of Canada Ltd. Mr. L. B. Gray, Experimental Shop Manager, Orenda Engines Ltd., presented the first paper which was entitled "The Machining and Welding of Titanium".

In this paper, Mr. Gray described the facility with which commercially pure and alloyed titanium can be machined. This information was found to be very interesting since much of the literature on the subjct emphasizes the contrary. A detailed description was given by the speaker of Orenda's milling, vertical and horizontal broaching and shaping of this material.

The second item in titanium fabrication which Mr. Gray described, was his company's experience with fusion welding of the metal. Their welding is done in a chamber which completely encloses the work and from which the atmosphere has been purged and replaced by an inert gas, such as argon. The importance of excluding such reactive gases as oxygen, nitrogen and hydrogen, from areas of the titanium which are heated during welding, was stressed by the speaker. The absorption of any or all of these gases imparts a brittleness to the titanium, which under certain circumstances can be to a prohibitive degree.

Mr. Gray touched briefly on other fabricating operations, such as the forming and forging of this comparatively new material.

It was obvious that the speaker had put a great deal of effort into preparing his paper, which was well illustrated by slides. Unfortunately it appeared that the audience did not contain many who were particularly interested in this subject since very few questions were asked of Mr. Gray. A paper of this calibre should have provoked a great deal of discussion from the audience since its subject matter is so timely.

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The paper given by Mr. H. L. McKeown, Director of Operations, Manufacturing Division, Canadair Ltd., was entitled "Transition from Small to Large Aircraft Manufacturing" and dealt with some of the problems of preparing for CL-28 production, the largest aircraft to be produced in Canada to date. He stressed that this was a current problem and, therefore, not entirely resolved and his talk emphasized the necessity for a revision in basic thinking and methods in order to hold direct and overhead costs within practical limits and the marked effect of the changeover on capital and facility utilization.

To illustrate these points, he outlined prior production programmes and then reviewed the approach to CL-28 production, which he divided into four categories, namely, People, Planning, Plant and Production. In the first he spoke of his Company's scheme of organization in the Manufacturing Division, in the second of their simplification and elimination policy, both categories relying on an equal measure of "old-fashioned" and modern methods for efficiency, in the third of the specific problem of floor area required in the plant – approximately 2½ times that for an F-86 – and problems of hangaring and pre-flight. Dealing with Production, he showed that the main difference was that of long flow times and large work assignments infrequently repeated, requiring far greater supervision and skills than heretofore.

Finally, returning to processing, Mr. McKeown pointed out that the processes required are basically similar to those of the F-86 and T-33 but the problem is again one of size, which is apparent through all phases from fabrication to assembly.

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The third paper of the Manufacturing Session, presented by Mr. H. F. Young, Chief Production Engineer, Avro Aircraft Ltd., was entitled "Machining Approach to Aircraft Production".

The subject covered in this paper is one that takes more and more importance in the manufacture of present-day supersonic aircraft, where the successful performance of the aeroplane is dependent on close tolerances at all stages of fabrication.

Mr. Young dealt specifically with the problems that were met in the current Avro programme and the methods used to solve these problems; with the help of slides, he also gave a comprehensive description of the various pieces of equipment used in the machining of skins, spars, ribs and other structural members.

Some of the points highlighted in Mr. Young's paper were:

(1) A special specification material with ultrasonic quality requirement is needed to produce sound machined components.

(2) Rolled plate and hand forgings are the materials mostly used to satisfy technical and economic requirements.

(3) Stretcher stress relieving with elongation of 2% is needed on rolled plate to prevent distortion in machining.

(4) Machining has to be tailored to suit the work; most of it is of the copy milling type with automatic tracing features.

(5) Feeds, speeds and horsepower to suit the light alloys must also be used for most efficient operation; metal removal in the order of 375 cubic inches per minute is not unusual in this type of machining.

(6) The necessity of close tolerances is further complicated by fuel tightness requirements in integral fuel cell structures; hand finishing must be employed to achieve satisfactory results.

**Morning Session May 4th**
**Design**

Reported by A. K. Hugessen, W. Symmons and J. D. Agnew

The Chairman of this session was Mr. J. L. Orr, Director of Engineering Research, Defence Research Board, substituting for Mr. E. C. Garrard, Chief Designer of the Fairey Aviation Company of Canada Ltd., who was unavoidably absent.

F/L B. D. Darling of Air Materiel Command, R.C.A.F., presented a concise account of design trends of ground handling equipment and described the machinery of procurement for the R.C.A.F.

The rapid growth of aircraft maintenance requirements since World War II and the increasing importance of ground equipment were outlined by the speaker. Current trends in ground equipment design include the increased use of self-propelled vehicles for better availability, combining of two or more maintenance facilities into multi-purpose units and utilization of aircraft type components. Design limitations, however, are enforced by the need for simplicity of operation and maintenance of the ground equipment and the requirement for air transportability.

F/L Darling then traced the steps in obtaining ground handling equipment for the R.C.A.F. Development is the responsibility of the Director of Air Engineering at A.F.H.Q., logistics and procurement are the function of Air Materiel Command and the Department of Defence Production is the purchasing agency. Contracting is done by open tender and the R.C.A.F. must make provision in future to obtain design rights and production drawings on equipment thus purchased in order to assure continuity of product.

Following presentation of the paper, a brief discussion period was held. In response to questions from the audience, the speaker explained the necessity of air transportability and discussed the difficulties of powering equipment for use both in the hangar and on the flight line.

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The next paper, entitled "The Comet 4 – Design and Operational Considerations" was written by G/C J. Cunningham, Chief Test Pilot, and Mr. R. E. Bishop, Design Director, of the deHavilland Aircraft Company, Ltd. G/C Cunningham presented the paper which included some interesting facts about the Comet 4's predecessors and the changes which have been introduced into the new aircraft.

The observations on the structural integrity of the Comet 4 were particularly interesting, though the statement, appearing in the preprint, "Should however cracks occur due to manufacturing error . . . the rate of propagation of the cracks would be so slow that they would readily be seen before they could possibly reach a dangerous magnitude" apparently refers to cracks which are initially undetectable; the aircraft would hardly be accepted with any known cracks in its primary structure, but this point was not made clear.

G/C Cunningham gave a good case for medium size passenger aircraft; the idea of sitting six abreast has no appeal. However, the real emphasis of the paper lay on the importance of the integrity of materials, first-class workmanship and meticulous inspection.

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The third paper entitled "Lift and Trust Creating Systems – Their Application to Short- and Vertical-Takeoff Aircraft" was written by Mr. F. C. Phillips, Chief of Aerodynamics and Preliminary Design, and Mr. K. Irbitis, Preliminary Design Engineer, both of Canadair Ltd. It was read by Mr. Phillips.

Mr. Phillips began his talk by referring to a recent editorial in the Canadian Aeronautical Journal, written by Mr. J. L. Orr, in the light of which he undertook to observe a "Be Kind to Non-aerodynamicists Week" and to keep his presentation comparatively free of the usual forms of expression so dear to the hearts of Aerodynamicists. (A promise well kept and much appreciated by the writer.)

The authors had gone to great pains to prepare excellent slides, which were used in conjunction with the delivery of the paper, and showed a most intriguing film of a helicopter blade in motion, taken by a camera mounted at the hub and photographing outward. The contortions of the blade came as a shock to some of those in the aviation industry, other than the aerodynamics and structures groups. The film was loaned by the McDonnell Aircraft Corporation of the U.S.A.

The paper itself was a very complete and concise summary of a broad subject, reviewing the many and varied forms

**Design Session: (l to r) F/L B. D. Darling, Mr. K. Irbitis and Mr. F. C. Phillips, Mr. J. Cunningham and Mr. P. C. Garratt (General Manager, DeHavilland Aircraft of Canada, Ltd.).**

**Maintenance and Operations Session: (l to r) Mr. R. N. Redmayne, Mr. A. E. Ades and G/C E. R. Johnston (Chairman), and S/L J. E. Neelin.**

of V.T.O.L. and S.T.O.L. techniques now practised or under discussion. It aroused a great deal of interest but unfortunately – and unavoidably – it was rather long for the time available and no discussion developed.

**Afternoon Session May 4th**
**Maintenance and Operations**
Reported by E. R. Fawcus and J. R. Hutton

Under the direction of G/C E. R. Johnston, Chief Staff Officer, Air Transport Command, R.C.A.F., the session was opened by Mr. R. N. Redmayne, Manager of the Air Industries and Transport Association. Some 100 members and guests attended.

Mr. Redmayne's subject "The Changing Aspect of Northern Flying" was most interesting and might be regarded as an inspiration to the young men to come who, seeking recognition and advancement, may in so doing contribute to the development of a comparatively unknown part of Canada.

The speaker described transportation, in all its forms, as the backbone of Canada's development and, starting with an account of the hardy group of bush pilots and air mechanics, who ventured into the deep North without airports, weather information, accurate maps or reliable aircraft, he reviewed the opening of the Canadian north by air transport.

In his interesting outline of the part played by aircraft in the establishment of the DEW line, Mr. Redmayne gave a graphic description of the difficulties encountered when the project was first reconnoitered and paid tribute to the outstanding work of Captain McGinnis in this connection.

In conclusion the speaker pointed out that such projects as the DEW line had established facilities for the further development of northern flying, which could be used to great advantage in the exploitation of the natural resources of the area. He suggested that all the interested organizations in Canada should consider holding a symposium on arctic flying to add to the knowledge of a subject of immediate importance to all engaged in Canadian aviation.

Mr. A. E. Ades, Assistant Director of Engineering, Trans-Canada Air Lines, was the second speaker. His subject was "Airline Engineering Evaluation of Transport Aircraft".

This paper was an admirable study of the many inter-related factors affecting the selection of an aircraft for some specific service. The underlying theme was Trans-Canada Air Lines' choice of a 5½ million dollar aircraft, weighing 300,000 lb, cruising at nearly 600 mph, for the Atlantic route, and although Mr. Ades did not divulge what the decision would be, he gave a very complete account of the analysis and thinking which such a problem demanded. By means of charts and graphs, Mr. Ades demonstrated the comparative features of turbo-jet, turbo-propeller and piston-engined aircraft and, in summary, expressed the belief that for the Atlantic route the turbo-jet held the overall advantage.

Finally the speaker touched on a few factors outside the airlines' control, such as the need for new runways and terminal facilities and more rapid development of navigational and approach aids.

The last paper of the afternoon session "Field Data Analysis" was presented jointly by S/L J. E. Neelin and Mr. B. Larmour, from Air Materiel Command, R.C.A.F.

An interesting case for statistical treatment of field data was given in considerable detail and should be an excellent reference work for all engaged in the analysis of field data.

It was demonstrated how, by the use of equipment life curves, marginal failure probability curves and finally component classification of the general malfunction analysis, proper control of equipment design, initial procurement, inventory control and maintenance procedures could be established.

The necessity for machine processes to analyze the detailed information received from the field was stressed.

The active discussion which followed this paper showed the keen interest of both industry and the operators in this subject.

**Afternoon Session May 4th**
**Aerodynamics**
Reported by S. J. Pope

A capacity audience enjoyed three widely differing aerodynamics papers, under the able chairmanship of Dr. D. C. MacPhail.

The first paper, "An Experimental Investigation of the Effect of Surface Roughness on the Drag of a Cone-cylinder Model at a Mach Number of 2.48", was presented by Dr. J. H. T. Wade, Aerodynamics Engineer, Orenda Engines Limited.

The study indicated two important conclusions. Firstly the experimental turbulent skin friction coefficient was of

the order indicated by Cope's work. For a given Reynolds Number it was also shown that the skin friction coefficient was only slightly less than that given by the von Kármán formula for subsonic flow. The second conclusion was that the permissible roughness to avoid additional drag followed the same laws as for subsonic flow. Both these conclusions would be of comfort to the practising engineer.

It was apparent from the early part of the lecture that the measurement of surface roughness involved considerable experimental difficulties.

The second paper, by Mr. J. Morris, Assistant Chief Aerodynamicist, Avro Aircraft Limited, was entitled "Some Performance Problems Associated with a Mach 2 Fighter".

The case was examined for a fighter with 2g capability at a combat height of 60,000 ft, yet which retained normal take-off and landing performance. Graphs were presented to show the variation of drag coefficient and maximum lift/drag ratio with Mach Number for a delta wing of aspect ratio 2 with four alternative tail configurations. It was shown that achieving fore and aft trim had a marked effect on both drag coefficient and lift/drag ratio and that the order of preference from this viewpoint was, canard, rear tail, tailless with full span elevons, tailless with part span elevons. It was also made clear that centre of gravity position had a strong influence in this respect for the tailless configuration and that control of the centre of gravity position in flight over about 10% of the mean chord would be worthwhile, although difficult to achieve.

Further study was directed towards the desirable wing loading that such a fighter should have, together with a consideration of aspect ratio and sweepback angle that should be selected.

As was pointed out by the lecturer, the arguments were not conclusive as he had not introduced the effects of corresponding weight changes.

The third paper was entitled "Boundary-layer Induced Noise in the Interior of Aircraft", by Dr. H. S. Ribner, Research Associate, Institute of Aerophysics, University of Toronto. The author introduced his subject by an explanation of the nature of pseudo-noise that is generated as tiny, local variations of pressure within the boundary layer and showed that this would not, of itself, produce audible noise. He led on to a consideration of the difference in noise level within the aircraft that would result from the presence of standing, as distinct from running, waves along the fuselage outer skin. This led to a proposal that fuselages should be constructed by attaching the stringers to the outside of the frames and then the skin to the stringers, so removing any direct attachment between the skin and frames. This technique was expected to minimize the presence of standing waves and so reduce the noise level within the fuselage.

Other proposals for noise reduction within the fuselage were, the addition of more insulation rather than greater skin gauges, the increase of wall stiffness at the same weight, e.g. by honeycomb construction, and the provision of internal damping for the skin by the use of sandwich construction with viscous layer. Reduction of boundary layer thickness by suction was also mentioned, but it was realized that the equipment would be bulky and heavy.

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*Copies of Papers*

A limited number of copies of some of the papers presented at the Annual General Meeting on the 3rd/4th May are obtainable from the Secretary. Price 25c each.


# INTERNATIONAL MEETING
# I.A.S./C.A.I.

## ROYAL YORK HOTEL
## TORONTO

## 26TH AND 27TH NOVEMBER 1956

# THE McCURDY AWARD — 1955

*Gazette Photo*

**Mr. J. H. Parkin (r) receiving the McCurdy Award for 1955 from the Hon. J. A. D. McCurdy**

THE McCurdy Award for 1955 was presented to Mr. J. H. Parkin, Director of the National Aeronautical Establishment and of the Division of Mechanical Engineering, National Research Council. The presentation was made by the Hon. J. A. D. McCurdy at the Annual Dinner of the Institute, which took place in Montreal on the 3rd May 1956.

The Citation reads as follows:—

Mr. J. H. Parkin is selected as the winner of the McCurdy Award for his unique contribution to the establishment of aeronautical research in Canada and his untiring leadership in this field.

On graduating in Applied Sciences with honours from the University of Toronto in 1912, Mr. Parkin was concerned first with a variety of design and development problems in munitions manufacture; and then, in 1917, with the building of a wind tunnel at the University of Toronto. In this wind tunnel he conducted many design investigations for new aircraft, the first of these being the Vickers "Vedette", used for many years by the R.C.A.F.

In 1929, Mr. Parkin moved to the National Research Council where he has devoted twenty-seven years to the building and operating of the main aeronautical laboratories in Canada. When their evolution led to the formation of the National Aeronautical Establishment in 1951, Mr. Parkin was chosen as the first Director.

During the whole time that he has been with the National Research Council, he has acted as Adviser to the R.C.A.F. and to civil aircraft constructors and operators on all aspects of research and design phases of aeronautics; through the active cooperation received from Mr. Parkin and his staff, considerable technical progress has been made.

Mr. Parkin has written numerous papers pertaining to various branches of aeronautics; and, by his initiative, indefatigable labour and inflexibly high standards, has established the excellent reputation of Canadian aeronautical research. His work, over so many years, has had a profound influence upon aeronautical design and development in this country.

The McCurdy Award was established in 1953. It is awarded annually to a resident of Canada for achievement in design, manufacture or maintenance related to aeronautics. It is regarded as the pre-eminent award in the aeronautical technical field in Canada.

# ANNUAL REPORT

## Of The Council

*1955-56*

When the Council took office in May last year, it found itself in charge of a very healthy and vigorous organization, full of promise but displaying many of the characteristics of youth. It was still growing rapidly but it was anxious to begin to do something other than grow, and obviously its guidance would require a mingling of restraint and encouragement. The C.A.I. was reaching a difficult stage and, at the same time, the very growth of the Institute was imposing organic changes upon the Council itself.

Of the ten members of the new Council, only two had served on the original Steering Committee and Interim Council of 1953-54 and on the Council of 1954-55. The others were unfamiliar with the detailed work which had gone into the founding of the Institute and the agreed principles and many compromises upon which the whole concept of the Institute had been based. Moreover, with representatives from Vancouver and Winnipeg taking their places for the first time, problems of geography were introduced, making it very difficult for the Council to meet as frequently as it had done in the past. Consequently, during the succeeding summer months, delays occurred in such things as the handling of admissions, while the new members of the Council familiarized themselves with the thinking which had gone before and while procedures were evolved to overcome the new difficulties presented by the far-flung distribution of the constituent Branches. However, by September the Institute had hit its stride again and the subsequent progress has been satisfactory.

### COUNCIL

It has always been considered a cardinal point of our constitution that all Branches should be represented on the Council and the By-laws require one member of each Branch to be present to constitute a quorum at any Council meeting. In 1954-55 there had been relatively little difficulty in holding Council meetings at fairly short intervals because the Branches then in existence, at Montreal, Ottawa and Toronto, were situated within easy reach of one another. With the introduction of Councillors from Vancouver, and later from Winnipeg, the procedure had to be modified; obviously representatives from Vancouver could not be expected to visit Ottawa every six or seven weeks to attend Council meetings, neither could representatives of the other Branches frequently travel west.

Faced with this problem, the Council appointed an Executive Committee (already provided for in the By-laws but previously unnecessary) to carry on the routine work, such as admissions, the authorization of limited expenditures, and the like, during the intervals between full Council meetings.

The Executive Committee consisted of the Councillors representing Montreal, Ottawa and Toronto; one member from each of these Branches was required to constitute a quorum of the Committee. All members of the Council were kept fully informed of the meetings of the Executive Committee and, if a Councillor from Vancouver or Winnipeg could attend an Executive Committee meeting, he was entitled to take part in the deliberations and to vote.

The plan has worked well. The Executive Committee has met 10 times during the year and a Councillor from Winnipeg has managed to be present on several occasions. The Council, with representatives from all Branches, has met three times, including a joint meeting with the 1956-57 Council which was held yesterday. Matters arising during Executive Committee meetings, which the Committee has judged to be outside its competence, have been referred to all members of the Council by mail.

As already mentioned, our By-laws stipulate that at least one member from each Branch should be present to constitute a quorum at any meeting of the Council. It is also laid down that the Council, so constituted, should meet at least twice a year. Taken together, these are exacting requirements. Though we have managed to fulfil them during the past year, it has not been easy and they will continue to present a serious problem to future Councils. It will always require a real effort on the part of the Councillors to comply with this feature of our constitution but the effort must be made if we are to maintain our National character.

### COMMITTEES

Each of the Committees, other than the Executive Committee already mentioned, will present its report later, but at this time the Council would like to express its thanks to all of them for the excellent work that they have done, relieving the Council of a great deal of detail.

In addition to the Committees on Finance, Admissions and Publications, two new Committees have been appointed this year, namely the Education and Training Committee and the National Programmes Committee. Without encroaching upon their respective reports, it is perhaps appropriate to comment upon the work of all the Committees, from the Council's point of view.

#### Finance

This year the Finance Committee has been situated in Toronto and has comprised Mr. C. J. Luby, Mr. I. M. Hamer, Mr. S. E. Harper and Mr. L. D. Clarke. The support from Sustaining Members has been very generous and, while the Institute has not been in a position to be extravagant, its financial problems have been a good deal easier than they were in 1954-55. The Finance Committee has been active in guiding and controlling expenditure on such new projects as the Journal and the establishment of the new Headquarters of the Institute, and in simplifying the Institute's accounting procedures. The Committee's budgetting has been remarkably accurate throughout the year and, as its report will show, it has left the Institute in a healthy financial position at the conclusion of its term of office.

#### Admissions

The Admissions Committee, like the Council, has been faced with the requirement that it should contain a representative from each Branch. The underlying purpose of this requirement is to attain consistency in the grading of applicants, but of course it presents diffi-

culties when the Branches are great distances apart. The Committee has consisted of G/C C. W. Crossland (Ottawa), Professor T. R. Loudon (Toronto), Mr. H. A. Reid (Montreal), Mr. I. A. Gray (Vancouver) and Mr. R. C. Guest, later replaced by Mr. A. S. Jackson (Winnipeg). They have conducted all their business by mail and they so organized their work that the time taken in the whole procedure, from receipt of an application to the admission of a member, seldom exceeded three months. This is a very good performance, when one considers that it includes the unpredictable factor of procuring replies from all the References cited by the applicants.

The work involved in studying and assessing applications is exacting and the Council is most grateful to the Committee for the time which must have been spent in considering over 600 applications in the course of the year.

**Publications**

The Publications Committee which launched the Journal in April 1955 has continued in office, to provide the needed follow-through. Its members G/C H. R. Foottit, Mr. J. Lukasiewicz and Mr. H. C. Oatway, later joined by S/L W. M. McLeish, are all located in Ottawa to enable them to keep in close touch with the actual production of the publication. The results of their efforts are self-evident in the Journal itself.

The production of the Journal has laid a heavy load upon the Secretary; this was foreseen, but obviously it would have been unsound to take on additional staff to handle the Journal, until some experience had been gained on which the staff requirements and the financial implications could be assessed. In January, the Council decided to appoint Mrs. Ross as Assistant to the Secretary, with the Journal as her chief responsibility, and a Mrs. Whipple was taken on to replace Mrs. Ross in her secretarial and bookkeeping duties. This arrangement has relieved the Secretary a good deal; in particular he is no longer tied to Ottawa during the entire course of each monthly production.

In addition to the Journal, the Publications Committee has also produced the first List of Members. The first List was naturally costly and time-consuming but, now that the start has been made, future lists will be more easy to produce.

**Education and Training**

When Professor T. R. Loudon, Air Vice-Marshal E. W. Stedman and Mr. R. H. Guthrie were appointed to form a Committee on Education and Training, they were asked firstly to study the familiar and perennial complaint about the shortage of adequately trained people in Canadian aviation and, secondly, to suggest ways and means by which the C.A.I. might help. In complying with the first part of their terms of reference, the Committee prepared a 13-page questionnaire, which was sent out to all the major employers of technical manpower; the replies are now being analyzed and it is premature to make any observations. We feel however that the initiation and framing of the questionnaire is in itself a significant step forward. It is hoped that this next year will see more tangible results.

**Programmes**

In 1954-55 the details of the major Institute meetings were hammered out by the Council itself; and any coordination between Branch programmes, such as the arrangement of a visiting speaker to address two or more Branches on succeeding evenings, was undertaken by the Secretary. This year a National Programmes Committee was set up, under the Chairmanship of Mr. E. B. Schaefer and having as its members the Chairmen of the Branch Programmes Committees, namely Mr. F. W. Moore (Montreal), Mr. C. D. Long (Ottawa), Mr. R. B. McIntyre (Toronto), Mr. G. Ades (Vancouver) and Mr. J. J. Eden (Winnipeg). The success of this Committee in arranging the programme of the International Meeting in Ottawa last November leads us to expect great things of this Annual General Meeting; certainly the Committee did well then and we have a very promising and attractive programme on this occasion. In coordinating the Branch programmes however, and in rendering assistance to the Western Branches in the procurement of films and speakers, there is room for improvement; the task is a formidable one and we have been exposed to some difficulties. A great deal has been learned this year and no doubt future National Programmes Committees will benefit from the experience and the recommendations which the retiring Committee will be able to pass on to them.

**INSTITUTE MEETINGS**

The International Meeting in which we joined forces with the I.A.S. for the second time, was held in Ottawa in November. The I.A.S. arranged for five of the ten speakers and the C.A.I. for the other five. As in 1954, the I.A.S. handled all the printing of notices, etc. We were very glad to welcome an increased number of American visitors this year and we hope that this trend will continue in future years. We believe that this joint meeting with the C.A.I. is becoming recognized as a permanent feature of the I.A.S. calendar and it has already been proposed that the next I.A.S./C.A.I. meeting should be held in Toronto next fall.

**W. RUPERT TURNBULL LECTURE**

The International Meeting last November was notable as the occasion of the first presentation of the newly established "W. Rupert Turnbull Lecture". It was given by Mr. J. H. Parkin, Director of the National Aeronautical Establishment, on the appropriate subject of Dr. Turnbull himself. It was a memorable lecture and we consider the series to have been inaugurated in a manner worthy of its standing.

**MEMBERSHIP**

The Admissions Committee will report on admissions. As regards total membership, the membership at the end of March was 1,470. This total takes into account the 77 members lost during the year from death, resignation or non-payment of dues. In the last category, 9 have since been reinstated, so that it might be said that our membership on the 1st April was 1,479. At the Council meeting held yesterday, 63 new members were admitted, raising our total to 1,542. These figures compare with a membership of 992 on the 1st April last year and 1,103 at the last Annual General Meeting; an increase of about 50% in the year – and applications for membership are still coming in steadily.

**BRANCHES**

Each Branch has maintained a monthly schedule of meetings since last September. Furthermore, a new Branch, at Edmonton, held its inaugural meeting last January and has held meetings monthly since then. Vigorous measures are now being taken to increase the membership at Calgary, Cold Lake and Quebec City to enable Branches to be formed at these three places; almost certainly Branches will be established there during the coming year. Halifax has been a little disappointing but there are now signs that interest is reviving in that district; obviously there ought to be a Branch of the C.A.I. at this centre of naval aviation.

At the end of last March, the membership in Toronto stood at 548, in Montreal at 383, in Ottawa at 205, in Vancouver at 81, in Winnipeg at 78 and in Edmonton at 22.

A noteworthy development during the year has been the establishment of a Student Section of the Toronto Branch and considerable interest has been shown in setting up similar Student groups in Vancouver and Calgary and, to a lesser extent, in Montreal. Student activities are an important part of the Institute's work and Toronto is to be congratulated for the lead it has taken in this field.

**HEADQUARTERS**

In October the Headquarters offices of the Institute were moved into the Commonwealth Building in Ottawa. This is a new building and the 790 sq ft taken by the Institute was partitioned and laid out to our own requirements. There are two large rooms, one of which doubles as the Secretary's office and a Council room. It is also used for various committee meetings. Our Headquarters staff is now 4, including the Secretary.

**AMENDMENT OF THE BY-LAWS**

Reference should be made to an Amendment of the By-laws which was initiated by the Council and voted upon by the general membership in March. It is now awaiting approval of the Secretary of State, as required by the terms of our Charter. The Amendment covered, in fact, four amendments, of which the most important restricts the numbers of members representing the bigger Branches on the Council. Perhaps the most significant feature of this Amendment is that it includes nothing of any major importance and that the By-laws, as originally established, have proved to be workable and generally satisfactory in two years of operations.

**ELECTION OF FELLOWS**

The election of Fellows is an annual responsibility of the Council. To be elected to this grade of membership, a member must have been an Associate Fellow of the Institute for at least a year and be nominated for election by members of the Council or by four Fellows. In accordance with this procedure the following have been elected Fellows this year,

Mr. P. B. Dilworth
Professor B. Etkin
Mr. I. M. Hamer
A/V/M A. L. James
Mr. R. A. Neale, and
Mr. B. S. Shenstone

**HONORARY FELLOWS**

It is a pleasure to announce that the Council has appointed Air Marshal W. A. Curtis an Honorary Fellow of the Institute.[a]

**PATRON**

This report of the year would not be complete without repeating the announcement made at the International Meeting last November, to the effect that His Royal Highness the Duke of Edinburgh has consented to become the Patron of the Institute. This Royal Patronage confers high honour upon us and upon the technical accomplishments of Canadian aviation which our Institute, in some small measure, represents.

**NEW COUNCIL**

Yesterday the retiring Council met with the Councillors recently elected by their Branches to represent them on the Council next year. Since Councillors have two year terms, some members of the retiring Council will of course continue as members of the Council for 1956-57, thereby providing the overlap which is so desirable.

At yesterday's meeting, the members of the new Council elected from among their number the President and Vice-President for the coming year. As a result the new Council is constituted as follows:

*President*–Mr. T. E. Stephenson (Ottawa)

*Past President*–Mr. R. D. Richmond

*Vice-President*–Mr. E. B. Schaefer (Montreal)

*Councillors*–

Mr. J. C. Floyd (Toronto)
Mr. W. D. Hunter (Toronto)
Mr. S. L. Britton (Toronto)
Mr. R. B. McIntyre (Toronto)
Mr. R. J. Conrath (Montreal)
G/C H. R. Foottit (Ottawa)
Mr. T. W. Siers (Vancouver)
Mr. A. T. Gilmour (Vancouver)
Mr. D. A. Newey (Winnipeg)
Mr. H. W. Grant (Winnipeg)
Mr. C. C. Young (Edmonton)
Mr. G. L. Best (Edmonton)

These then are the men who will guide the Institute in its third year. Their task will be a fruitful and rewarding one, if they enjoy the enthusiastic support and cooperation which we have had. So long as members regard the C.A.I. as something in which they have a personal interest, something to which they can all contribute their ideas and suggestions knowing that they will be seriously considered, so long with the Institute thrive and serve its purpose in Canadian aviation. Its membership must grow and the scope of its services must be widened to cover many more of the activities of its members. There is a lot to be done and we send the new Council on their way with every good wish for a successful year.

[a]This was announced at the Annual Dinner on the 3rd May.

## Report of the Publications Committee for the year 1955-56

The principal work of the Publications Committee has revolved around the Canadian Aeronautical Journal; a somewhat secondary project has been the List of Members. Both have given us a few anxious moments but on the whole we believe the results to have been satisfactory.

**THE JOURNAL**

**Material**

The Journal has now been issued for little more than a year. In its early days some doubts were expressed about the supply of technical material suitable for publication in a journal of this sort but though the supply has not been abundant, it has proved to be adequate. We have tried to run four or five technical articles in each issue and we have generally succeeded.

The bulk of the material which has been published has been drawn from papers presented at Institute and Branch meetings. The writing of technical papers, expressly for publication, has not been developed in Canada in the past, but several excellent contributions have been submitted in the course of the past year and there is evidence that the habit is growing.

There has been some criticism on the lack of papers covering certain specific fields of aeronautical activity. The Committee has done all in its power to overcome these deficiencies but obviously it can use only what is available. The journal of a technical society should not republish material which has appeared elsewhere and, if the supply of original material in any particular field is limited, there is not very much the Committee can do about it. It can only urge members to submit material from their own experience and to try to persuade their friends to do likewise.

**Editorial Board**

It will have been noted that an Editorial Board has been appointed from experts in various fields and papers sub-

mitted have been referred to the Board for comment and opinion. The Committee wishes to express its thanks to these gentlemen for their work, which has been of great assistance and value in maintaining the standard.

Not only has the Editorial Board helped in the selection of papers but it has done much to promote their writing and submission. The Publications Committee, situated in Ottawa, is seriously limited in the extent to which it can encourage people to write papers for the Journal and it is indebted to the members of the Editorial Board who have effectively extended the influence of the Committee to many cities in Canada where authors are likly to be found. This is not an Editorial Board function but it is one which they were asked to undertake and which they have performed with some success.

**Editor**

It was recognized at the onset that the production of the Journal would entail a good deal of work by the Secretary and his staff, and that sooner or later a full-time editor would have to be employed. However, the financial success of the Journal was by no means certain and we could not contemplate the employment of additional staff until the Journal had shown signs of paying for itself; in fact it was originally suggested that an editor should not be employed until the revenue from the Journal was sufficient to pay at least half of his salary.

Early this year, however, it was realized that the Secretary must be given some measure of relief and the appointment of an editor could not be postponed, even though the Journal was a long way from being self-supporting. The Council decided that the Journal was sufficiently worthwhile to warrant the provision of the necessary help from general Institute funds – in effect, that the Journal should be treated as one of the Institute's projects – and a compromise arrangement was made. Mrs. Ross, who had been responsible for all the secretarial and bookkeeping work of the Institute, was appointed to take charge of all the detail work associated with the Journal production and Mrs. Whipple was added to the staff to take over Mrs. Ross' former duties. This plan has worked well. However, it must be realized that Mrs. Whipple's appointment is directly attributable to the production of the Journal and perhaps should be regarded as a charge against it. As will be seen from the figures which follow, there is still some way to go before our publications "pay for themselves".

**THE LIST OF MEMBERS**

The preparation of a List of Members had been postponed until such time as the membership of the Institute had attained some measure of stability. But membership went on growing and growing and it was felt that the List could not be put off much longer. Accordingly, the first List was prepared last December. Its production involved an enormous amount of work but we hope that, now that a start has been made, future Lists will prove to be less formidable and less costly.

**FINANCE**

**The Journal**

The production and distribution of the Journal has cost $12,816.13 during the fiscal year. Our advertising revenue has been $8,432.49 and revenue from subscriptions $2,804.36–a total of $11,236.85. Thus on the bare Journal the loss has been $1,579.28. (The cost of the old C.A.I. Log during 1954-55 was about $2,250. We derived no revenue from the Log and furthermore only 7 issues were made, as against 10 issues of the Journal in 1955-56.)

There has been some revenue from reprints of certain papers which have appeared in the Journal. This has amounted to $69.85 and it is perhaps fair to put this to the credit of the Journal, reducing the loss to $1,509.43.

But the prospects are improving rapidly. Circulation of the Journal has increased from 1,300 in April 1955 to 1,850 in March 1956. The Journal is becoming more widely known and at present about 60 universities and libraries in the U.S.A. and overseas subscribe to it. With this increase in circulation and the growing realization that the Journal reaches the majority of the responsible people in the aviation industry in Canada, advertising revenues are increasing. Last March the advertising revenue exceeded the cost of production by about $300 and the trend is continuing. We have been told that a proportion of 60% text to 40% advertising is a healthy figure for a technical journal; in March we nearly attained this ratio with 40 pages of text etc., to 16 pages of advertising. The big losses were experienced, of course, in the early issues; we are overhauling our losses and we will soon break even if we resist the temptation to increase the size of the Journal as our advertising increases.

**The List of Members**

As stated, the List of Members was a costly business. The cost of production and distribution was $1,007.00; it carried no advertising and was distributed free of charge. Possibly this publication will always have to be carried by the revenue from the Journal, but the matter has not yet been given any serious thought; some other way of financing it may be devised.

**CONCLUSION**

In conclusion, we believe that the publications of the Institute are developing satisfactorily. The Canadian Aeronautical Journal has made a good start; its popularity is growing and it is beginning to serve as an effective and much needed vehicle for the dissemination of Canadian contributions to aeronautical knowledge; the supply of good material is being maintained. Admittedly the Journal is not fully developed but a good foundation has been laid and there seem to be no serious restrictions to further development and the embodiment of new ideas and new features. The future is full of promise.

## Report of the Admissions Committee for the year 1955-56

The Admissions Committee is composed of the Chairmen of the Branch Membership Committees, who are appointed by the Chairmen of the Branches. The Chairman of the Admissions Committee, in turn, is appointed by the President.

The Admissions Committee for 1955-56 was organized near the end of June 1955, with the following membership:
G/C C. W. Crossland, Ottawa (Chairman),
Professor T. R. Loudon, Toronto,
Mr. H. A. Reid, Montreal,
Mr. I. A. Gray, Vancouver,
Mr. R. C. Guest, Winnipeg.
During the year Mr. Guest retired from the Committee and his place was taken by Mr. A. S. Jackson. With the formation of the Edmonton Branch, Mr. C. C. Young was added to the Committee.

A few words regarding the Committee's policy may be in order. If the C.A.I. is to acquire any public recognition, it is essential that each applicant be fully qualified for the grade to which he is admitted. It is not enough to have a certain number of years of training and experience: the applicant's achievements and status in the aeronautical community are the prime considerations, apart from the minimum requirements for experience. In some cases it is difficult to decide what credit to allow for technical school training, if any. The By-laws make an allowance of four years if a candidate has graduated from a school of engineering or science recognized by the Council. This clearly implies that the possessor of an engineering or science degree may be allowed credit for four year's experience. In practice, the Committee has also given credit for two years to candidates who have completed the three year course in aeronautical engineering of the Provincial Institute of Technology and Art, of Calgary. There appears to be a need to assess the value of other similar training courses and to make corresponding allowances for them, but this has not yet been done, mainly owing to lack of knowledge of such courses.

The grade of Technician is intended for apprentices and others with less than four years experience. A number of members have misunderstood this in making recommendations on the grading of applicants. A candidate who has a minimum of four years technical aviation experience is entitled to the grade of Technical Member.

When a candidate, who is in an administrative position, has a background of technical experience, he is given the appropriate technical grade even though he is no longer doing technical work.

The Committee believes that, to have attained the "recognized standing" required to be admitted to the grade of Member, a candidate should have responsibility for supervision of the work of others.

The following brief outline of the procedure for admitting a candidate may be of interest. The candidate sends his application to the Secretary of the C.A.I., who records it and sends an index card to the Branch Secretary. He also sends forms to the references named by the candidate. The application is then forwarded to the Chairman of the Admissions Committee, followed in due course by the forms completed by the references. At intervals of about a fortnight, the Chairman of the Admissions Committee makes a list of applicants, recording his vote, and passes it by mail to the other members of the Committee, each of whom votes on every candidate. Applications from Students are not circulated, as there is no doubt about their grading. The Chairman finally prepares a report for the Council, based on the votes of the Committee. This whole process may take three or four months but it is the fairest system we have been able to devise and it brings each Branch into the national picture. Applications for advancement in grade are similarly processed.

Since the last annual meeting, the Committee has made 9 reports to the Council. The number of candidates recommended for admission to each grade is given below:

| | |
|---|---|
| Associate Fellow | 31 |
| Member | 195 |
| Associate | 17 |
| Technical Member | 156 |
| Student | 89 |
| Technician | 13 |
| Total | 501 |

Five members were recommended for advancement in grade to Associate Fellow, five to Member, and ten to Technical Member. Three other applications for advancement in grade were not recommended. In addition about 100 applications are being processed. About half of these are waiting for reference forms to be returned.

This rate of increase in membership is very gratifying and indicates that the C.A.I. is filling a real need. It is difficult to estimate our potential membership. It is undoubtedly very large, since the March 1956 issue of *Aircraft* reports that there are approximately 42,900 persons directly engaged in the manufacture, repair and overhaul of aircraft, aero engines, and aeronautical ancillary equipment.

## Report of the National Programmes Committee for the year 1955-56

The year 1955-56 of the Institute's Programme of meetings and activities for the membership was highlighted by two events of national scope and full programmes of Branch meetings throughout the year.

The two meetings, sponsored by the C.A.I. Executive and Council, included the International Meeting of the C.A.I. and I.A.S. held in Ottawa on November 3rd and 4th, 1955, and this present Annual General Meeting in Montreal on May 3rd and 4th, 1956. The International Meeting in November 1955, being a joint C.A.I.-I.A.S. effort, presented papers and discussions by both Canadian and U.S. authors, an inspection tour of the National Aeronautical Establishment Laboratories and the first presentation of a future annual lecture. This first W. Rupert Turnbull Lecture was ably delivered by John H. Parkin, Director, National Aeronautical Establishment. The 1956 Annual General Meeting culminates the 1955-56 year of national events.

The Branches of the Institute provided the membership with local meetings throughout the 1955-56 year. The older Branches, having been in operation for two years, planned and consummated fairly extensive programmes and it is most gratifying to be able to report that the newly formed Branches in the west swung into action upon formation with planned programmes.

In completing this brief report on 1955-56 programmes the Committee wish to express their gratitude to the people who have helped so much in the planning and execution of the National and Branch Programmes. Specifically, the Branch Executive of Ottawa and Montreal for handling all the difficult arrangement work for the two National Meetings, and most of all our dear friend and Secretary Charles Luttman and his staff.

In final conclusion, the retiring Programmes Committee Chairman is submitting some general observations and recommendations for the consideration of the newly appointed 1956-57 Programmes Committee Chairman.

## Report of the Education & Training Committee for the year 1955-56

As a result of the discussion at the Annual Meeting in 1955 on the Education and Training of Aeronautical Personnel, your Council appointed A/V/M E. W. Stedman, Mr. R. H. Guthrie and Mr. T. R. Loudon a Committee with the following terms of reference:

(a) To carry out a survey of supply and demand for trained aeronautical technical personnel in Canada.

(b) To advise Council on the spheres in which the C.A.I. might render assistance.

Your Committee held its first meeting on August 25th, 1955, at the plant of the Canadian Pratt & Whitney Aircraft Co. at Longueuil, electing Mr. Loudon Chairman, with Mr. Guthrie acting as temporary Secretary. It was agreed to ask Mr. Luttman to act as permanent Secretary to the Committee.

Mr. Guthrie presented a Questionnaire to be used in making a survey of the technical personnel situation in the aviation industry in Canada. After considerable discussion, Mr. Guthrie kindly agreed to give the matter further thought and to bring the amended Questionnaire to the next Committee meeting using the terms Professional Engineer, Technologist and Craftsman to outline the various phases of engineering endeavour in the industry. The question of the various methods of training was also discussed at length.

Four more meetings of the Committee were held at C.A.I. Headquarters on September 17, October 26, 1955, February 3, and April 20, 1956.

The Questionnaire was submitted to Council on September 28th and the comments received together with suggestions from Mr. Dymond of the Government of Canada, Department of Labour, were embodied in the final form. This was sent out to 80 selected aircraft firms and appropriate departments of the Armed Services on December 16th, 1955, asking for returns to be in by January 31st. This last date was later extended to February 29th.

The final returns of the Questionnaire have been circulated to the members of your Committee for assessment and are now in the hands of Mr. Dymond for his tabulation and comments.

It is felt that your Committee has fairly well fulfilled a large portion of Paragraph (a) of the terms of reference above. It is now appropriate to proceed more intensively with Paragraph (b).

Council has approved the suggestion that the Committee be enlarged to five members and Mr. W. A. B. Saunders, Vice-Principal of the Provincial Institute of Technology and Art at Calgary has consented to act. A fifth member will be added shortly. Mr. Kerr, Principal of the Ryerson Institute of Technology of Toronto, has also agreed to meet with your Committee; but unfortunately, as he is not a member of the C.A.I., he cannot be made an official member.

Council has also approved the suggestion that Branch Sub-committees reporting to the Central Committee be set up to consult with top level personnel in Education and Industry about the setting up of adequate facilities for training technical personnel. Your Committee is meeting with the Branch Chairmen regarding this matter.

It seems evident to your Committee from the information received that the main problem at present is the training of Technologists. There is a great need of more Technical Institutes and the providing of adequate technical courses suited to the aeronautical industry. Your Committee proposes to set up a C.A.I. standard of courses in this respect for presentation and use by the proper Provincial Training Centres.

It must be kept in mind that there would be nothing gained by the C.A.I. attempting to operate courses for a diploma such as is done in some other countries. This would have no standing in Canada. All educational institutions must be operated by the Provinces in order to get recognized standing. On the other hand, there should be no difficulty in getting Provincial Training Centres to use courses drawn up by the C.A.I.

The great problem is to get the public in general to recognize Technologist Diplomas as having high standing socially and commercially. This will be gone into by your Committee. While we recognize the great necessity of establishing training facilities, an even greater problem lies in getting an adequate supply of Technologist personnel. Ways and means will have to be outlined by your Committee with the help of the Branch Sub-committees.

It was felt that the problem of stimulating apprentice training of Craftsmen should not be gone into at present; but certainly it is vital if a supply of trained supervisors is to be forthcoming in the future.

With reference to Professional Engineers, there should be no difficulty in getting Universities to accept suggestions for courses. There is a big problem in getting undergraduates to take a greater interest in structural training, a matter which you Committee proposes to investigate. The excellent editorial by Mr. J. Orr in the May C.A.I. Journal gives a very good starting point. It is felt also that the importance of training in Electronics must be drawn to the attention of those interested in entering the aviation industry at the Professional level.

The question has been raised as to whether or not greater progress could be made if there were a paid individual who could travel around and stimulate interest and organize training matters. Your Committee feels that at the present time this would be a premature action. At present our ideas have not reached a firm enough basis upon which a permanent director could act. It should be recognized that we are not likely to get any one who is competent to take on this work for a small salary. This, with travelling expenses, could very quickly bankrupt the C.A.I. It has been suggested that later on, if necessary, some retired individual might be obtained for a smaller salary. It is hoped however that with competent Branch Sub-committees we will get good results fairly quickly.

## Report of the Finance Committee for the fiscal year 1955-56

At the end of its second year of operation, the Institute's financial position is gratifyingly stronger than was forecast at this time last year. The audited statement for the 1955 fiscal year shows a surplus of $20,113.40 as against $3,911.69 at March 31st, 1955, an increase of $16,201.71.

Income for the year totalled $57,335.52. The Royal Aeronautical Society, the Institute of the Aeronautical Sciences and the Engineering Institute of Canada provided grants totalling $2,100.00, in accordance with their generous agreement to help establish our Institute. The Institute of Aircraft Technicians closed its books by transferring to the Institute $152.90.

Regular membership dues and entrance fees totalled $7,865.00, an increase of $2,908.00 over the 1954 fiscal year.

The Sustaining Members were most generous and contributed $31,260.00, an increase of $21,460.00 over 1954.

Expenditures during the year totalled $41,011.80. Remissions to branches amounted to $2,336.03, an increase of $1,280.03 over 1954.

Salaries and staff benefits amounted to $12,738.08, an increase of $4,950.78 over 1954. This increase was attributable firstly to the additional staff required to handle the Journal and the increased membership, and secondly to the fact that 1954 only reflected 8 months of office operation.

The operation of the Journal shows income of $11,635.72 as against expenditures of $13,157.83, a deficit of $1,522.11 which is substantially less than that allowed for in the budget. During the latter part of the year, revenue from advertising showed a substantial increase and there is good reason to believe that the Journal will be self-sustaining in 1956.

A scheme of staff benefits on a contributory basis was considered by your Committee during the year. A recommendation will be made to the incoming Council providing for staff benefits comparable to those received in Government and Industry.

During the early part of the year, your Committee in conjunction with the Secretary revised the accounting procedure of the Institute to ensure that its monthly statement, its budgetary forecasts and its annual financial statement could be presented on a comparable basis. In this regard, reference was made to the accounting methods employed by the Royal Aeronautical Society and the Institute of the Aeronautical Sciences.

During its formative years, the Institute must ensure that it builds up a sound financial base for future years' operations. With this object in mind, your Committee operated on the premise that, apart from the operation of the Journal, the affairs of the Institute during the past year were to be administered so as to produce as large an increase in the surplus account as possible.

Your Committee considers that the greatly improved financial position of the Institute, as reflected in the Auditor's statement which I will read to you shortly, should permit next year's Council to broaden the Institute's operations within the objects prescribed by the By-laws.

Until his retirement in March, the affairs of the Committee were administered under the most capable guidance of Mr. C. J. Luby, assisted by Mr. L. D. Clarke, Mr. I. M. Hamer and Mr. S. E. Harper. I feel sure that the Institute will wish to join us in expressing our appreciation to Mr. Luby and wishing him every success in his new appointment in England.

In conclusion, the Committee feel that this report would not be complete without recognition being given to the very gracious and able assistance received from our Secretary, Mr. H. C. Luttman, under what at times must have been somewhat trying circumstances.

***The Auditor's Report and Financial Statement are shown overleaf.***

## AUDITOR'S REPORT

To The Members,
Canadian Aeronautical Institute,
Ottawa, Ontario.

We have examined the accounting records of the Canadian Aeronautical Institute for the year ended 31st March, 1956, but we did not make a detailed examination of all the transactions in the year.

Subject to the foregoing, in our opinion, the following balance sheet and related statement of revenue and expenses have been drawn up so as to show the true and correct view of the financial condition of the Canadian Aeronautical Institute as at 31st March, 1956, and of its operations for the year ended on that date, according to the best of our information and the explanations given to us and as shown by the books.

ARMSTRONG, CROSS & CO.,
Chartered Accountants.

OTTAWA, Ontario,
18th April, 1956.

# FINANCIAL STATEMENT

# of

# CANADIAN AERONAUTICAL INSTITUTE

# for

# The year ended 31st March, 1956

## BALANCE SHEET

**Statement 1**

### ASSETS

| | | |
|---|---|---|
| **Current:** | | |
| Cash on hand and in bank | | $ 8,469.17 |
| Dominion of Canada bond | $ 1,516.87 | |
| Hydro-Electric Power Commission bonds | 11,970.00 | |
| | | 13,486.87 |
| Inventory of pins on hand for resale, at cost | | 148.58 |
| Accrued interest on bonds | | 35.00 |
| Accrued advertising revenue | | 2,001.37 |
| | | $24,140.99 |
| **Fixed:** | | |
| Furniture and fixtures | | $ 1,917.22 |
| Less: Accumulated depreciation | | 508.09 |
| | | 1,409.13 |
| | | $25,550.12 |

### LIABILITIES AND SURPLUS

| | | |
|---|---|---|
| **Liabilities:** | | |
| Accounts payable and accrued charges | | $ 2,912.66 |
| Fees received in advance | | 1,921.00 |
| Journal subscriptions received in advance | | 603.06 |
| | | $ 5,436.72 |
| **Surplus:** | | |
| Balance 31st March, 1955 | | $ 3,911.69 |
| Add: Net revenue for the year – per Statement 2 | $16,323.72 | |
| Deduct: Adjustments in revenue for year ended 31st March, 1955 | 122.01 | |
| | | 16,201.71 |
| Balance 31st March, 1956 | | 20,113.40 |
| | | $25,550.12 |

## REVENUE AND EXPENSES

**Statement 2**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Revenue:** | | | | **Expenses:** | | |
| Fees — Regular | $ 5,710.00 | | | Remissions to Branches: | | |
| — Entrance | 2,155.00 | | | Standard Allowances | $ 2,153.00 | |
| — Sustaining | 31,260.00 | | | Special Allowances | 183.03 | |
| | | $39,125.00 | | | | $ 2,336.03 |
| Grants: | | | | Publications Expense: | | |
| Institute of the Aeronautical Sciences | $ 1,000.00 | | | Journal | 12,816.13 | |
| Royal Aeronautical Society | 1,000.00 | | | Sundry technical papers | 341.70 | |
| Engineering Institute of Canada | 100.00 | | | | | 13,157.83 |
| Institute of Aircraft Technicians | 152.90 | | | Dinners, meetings, receptions | | 3,289.85 |
| | | 2,252.90 | | Meetings, printing | | 149.30 |
| Investment Revenue: | | | | Prizes and donations | | 257.25 |
| Bond interest | 252.04 | | | Membership routine | | 433.86 |
| Bank interest | 36.30 | | | Salaries, permanent staff | | 12,683.32 |
| | | 288.34 | | Staff benefits | | 54.76 |
| Publications Revenue: | | | | Rent, headquarters | | 1,607.50 |
| Journal subscriptions | 2,804.36 | | | Insurance | | 30.10 |
| Advertising | 8,432.49 | | | Telephone and telegraph | | 333.15 |
| Sundry technical papers | 398.88 | | | Office supplies | | 3,672.62 |
| | | 11,635.73 | | Travel and expenses | | 902.73 |
| Dinner meetings, receptions | | 3,582.55 | | Exchange and bank charges | | 121.44 |
| Registration fees | | 299.00 | | Legal and professional charges | | 362.00 |
| Lapel pins | | 152.00 | | Miscellaneous | | 83.93 |
| | | | | Headquarters office improvements | | 1,183.85 |
| | | | | Depreciation, furniture and fixtures | | 352.28 |
| TOTAL REVENUE | | $57,335.52 | | TOTAL EXPENSES | | 41,011.80 |
| | | | | **Net Revenue for the Year — To Statement 1** | | $16,323.72 |

## RECEIPTS AND DISBURSEMENTS

**Statement 3**

| | | | | | | |
|---|---|---|---|---|---|---|
| CASH ON HAND AND IN BANK — 31st MARCH, 1955 | | $ 3,132.76 | | **Disbursements:** | | |
| **Receipts:** | | | | Dinner meetings, receptions | | $3,289.85 |
| Fees — Entrance | $ 2,075.00 | | | Meetings, printing | | 149.30 |
| — Regular | 6,103.00 | | | Remissions to Branches, Standard Allowances | | 2,103.00 |
| — Sustaining | 31,810.00 | | | Remissions to Branches, Special Allowances | | 183.03 |
| Grants | 2,252.90 | | | Journal publications | | 11,321.79 |
| Bond interest | 217.04 | | | Sundry technical papers | | 341.70 |
| Bank interest | 36.30 | | | Prizes and donations | | 257.25 |
| Journal subscriptions | 2,983.42 | | | Membership routine | | 301.60 |
| Advertising | 6,431.12 | | | Salaries, permanent staff | | 12,683.32 |
| Sundry technical papers | 398.88 | | | Staff benefits | | 54.76 |
| Dinner meetings, receptions | 3,582.55 | | | Rent, headquarters | | 1,607.50 |
| Registration fees | 299.00 | | | Insurance | | 30.10 |
| Lapel pins | 152.00 | | | Telephone and telegraph | | 328.42 |
| | | 56,341.21 | | Office supplies | | 2,559.03 |
| | | $59,473.97 | | Travel and expenses | | 902.73 |
| | | | | Exchange and bank charges | | 121.44 |
| | | | | Legal and professional charges | | 312.00 |
| | | | | Miscellaneous | | 83.93 |
| | | | | Headquarters office improvements | | 1,183.85 |
| | | | | Hydro Electric bonds | | 11,970.00 |
| | | | | Headquarters office equipment | | 1,220.20 |
| | | | | | | 51,004.80 |
| | | | | **Cash on Hand and in Bank — 31st March, 1956** | | $ 8,469.17 |

# BRANCHES

## COLD LAKE

In the February issue of the Journal, we referred to the beginnings of a new Branch at the R.C.A.F. Station, Cold Lake. Since then they have been making very good progress and, though they have not yet applied for formal approval by the Council, they have already acquired about 30 members or applicants for membership, they have elected an Interim Executive Committee and they have held a technical meeting.

Their Interim Executive Committee comprises

Chairman–S/L R. G. Christie.

Vice-Chairman–Mr. J. H. Harrop

Secretary–Mr. R. W. Ellard

Treasurer–WO J. R. Davis

Mr. Ellard reports as follows on their first meeting:

The first meeting of the C.A.I. members at Cold Lake was held in the meetings room in the Airmen's Canteen at 8 p.m. on Wednesday, April 25, 1956. The guest speaker was F/O K. Weinstein, Beverley project engineer from the C.E.P.E. climatic detachment, R.C.A.F. Station Namao. He was supported by Mr. G. Hallet of Bristol Aero Engines Ltd. and Mr. R. Nicheman of deHavilland Propellers Ltd., both of whom are associated with the Beverley evaluation programme. The subject of the talk was the Blackburn Beverley and its winter trials.

Mr. J. Harrop acted as Programme Chairman and opened the meeting with a few remarks on the progress of the new Branch. He proceeded to introduce the speaker with a brief summary of the Beverley's long career, which started when he himself worked for Blackburn Aircraft.

F/L Weinstein explained the specific tactical role for which the aircraft was designed and commented that it could hardly be compared with the strategic type of transport normally used by the U.S.A.F. He went on to explain the construction of the aircraft, illustrating his talk with pictures and some details of performance and operation. He finally gave a summary of what the climatic detachment does to such an aircraft during an evaluation programme, further illustrated by photos of personnel carrying out engine changes in the open at sub-zero temperatures – of great interest to the members in Cold Lake.

A question period followed the talk, ending at 10 p.m. Mr. J. Harrop thanked the speaker for his efforts, refreshments were served and the meeting became a social occasion until 11 p.m.

The attendance register showed that 33 people attended the talk, despite a storm which started before the meeting.

## VANCOUVER BRANCH— STUDENT SECTION

A Student Section of the Vancouver Branch has now been formed at the Canadian Services College, Royal Roads, Victoria, B.C., and the following brief history of its development has been submitted by Cadet A. O. Manson, Secretary of the Student Committee:

The idea of forming a Student Section at Royal Roads was first thought of in the fall of 1955. Cadets D. Fraser and P. A. Flynn were the first Cadets to apply for Student membership in the Institute. They were contacted by Mr. R. J. McWilliams, Secretary of the Vancouver Branch, with the object of seeking suggestions for the organization of a Student Section. Approval of the College Authorities to proceed with the project was subsequently obtained. Since that time, Mr. McWilliams has worked hand in hand with the Cadets and with the College Adviser, F/L E. Simkins, in stimulating and furthering the formation of the Section.

On January 16, 1956, the Secretary of the Canadian Aeronautical Institute, Mr. H. C. Luttman, visited Royal Roads, together with Mr. McWillians. Both seemed enthusiastic over the possibility of a Student group at the College.

Mr. McWilliams again visited the College on March 16, 1956, during which time he instructed the Students on the choice of an Administrative Committee, and discussed various activities in which the Students could participate. Mr. McWilliams also spoke briefly on the subject of "Modern Methods of Aircraft Maintenance". The circumstances governing the growth of the maintenance system in use in pre-war years and, to a certain extent, still in use were touched upon. Wartime necessity speeded up the development of more efficient systems which, in post-war years, have been further developed. Systems of Progressive Maintenance and Planned Inspection have been based on the rational approach. Emphasis is given to a regular and controlled flow of work, the reduction of manpower expenditure and to improved reliability and regularity and increased utilization of equipment. The application of Production principles and Industrial Engineering methods have led to detailed planning procedures which result in improved quality coupled with a reduction in unit cost. Mr. McWilliams closed his remarks with a passing reference to the loss of glamour and romance as the art of maintenance submits to rationalization and the analytical approach and we enter the development phases leading to the science of aircraft maintenance.

At a later meeting a Student Committee was elected consisting of

Chairman–Cadet M. W. Stedman

Vice-Chairman–Cadet G. G. Hopp

Secretary–Cadet A. O. Manson

Membership Secretary–Cadet P. J. Dawson.

The Commandant of Royal Roads, Capt. Charles, R.C.N., was appointed Honorary Chairman, while the Director of Studies, Prof. Cook, was appointed Honorary Vice-Chairman.

At the present time, the Section has thirteen members. Five other Cadets have since applied for membership in the Institute and it is hoped that when the new Junior Term arrives next fall, the Section will be enlarged considerably. Eight students will graduate in the near future and will pass on to R.M.C. Kingston, where they hope to form another Student Section.

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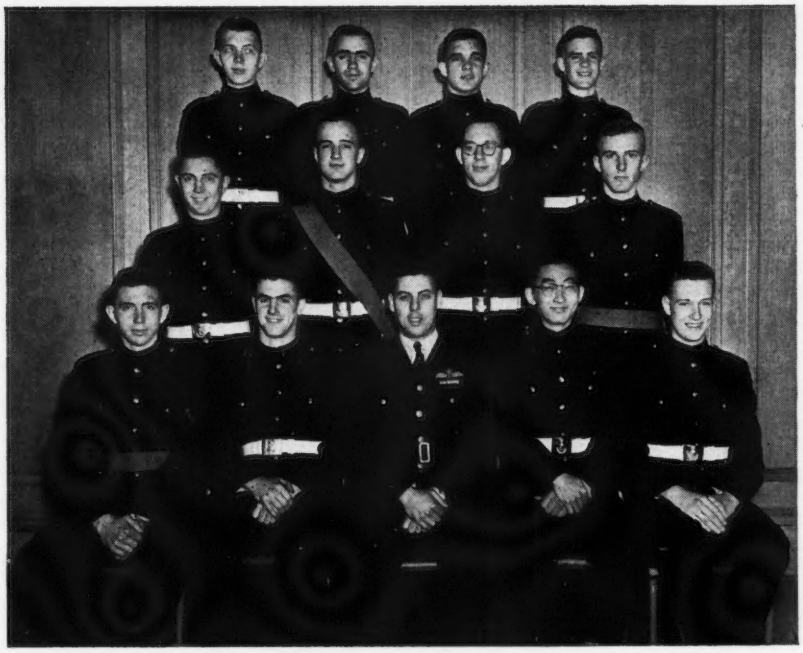
Royal Roads is a Tri-Service Military College situated a few miles from Victoria, B.C. Canada's future Service Officers, with the exception of the Naval Executive Branch, receive two years of education at Royal Roads and two more years at R.M.C. in Kingston, after which the majority of Cadets are chosen to attend one year at a civilian university to obtain their Arts or Engineering degrees. Naval Executive Branch receives two years education at Royal Roads, after which they are sent to England to continue their naval education.

The college year runs roughly parallel to a civilian college year and offers



**Vancouver Branch—Student Section members at Royal Roads. Front row (l to r) Cadets M. D. Thom, D. Fraser, F/L E. Simkins, Cadets K. V. Ujimoto, R. L. Walkington. Centre row (l to r) Cadets D. Hoffman, P. A. Flynn, E. M. Belovich, D. Allatt. Back row (l to r) Cadets G. G. Hopp, A. O. Manson, P. J. Dawson, M. W. Stedman. (Missing: Cadet J. G. Safar).**

approximately the same courses. It is during the summer months that Cadets receive their military training.

Twelve of the thirteen existing Student members are in the R.C.A.F. The other member is in the R.C.N. (Executive Branch). Five of the R.C.A.F. Cadets are in the Technical Branch, while the other seven are air-crew. Cadets Allatt and Belovich are taking their training in the Armament Branch while Cadets Ujimoto and Manson are training in the Telecommunications Branch. Cadet Dawson is in the Aeronautical Engineering Branch. Cadets Thom, Lafar, Walkington and Stedman are pilots, while Cadets Flynn, Hoffman and Hopp are observers. The Naval Cadet, Cadet Fraser, will finish his two years' course at Royal Roads this spring and will be training in England this summer.

The Staff Adviser to the Section, F/L Simkins, who figured largely in the organization of the Section, will be leaving the College soon to take up another posting on CF-100 training. His successor, F/L K. Lewis, a Sabre pilot from the R.C.A.F. Air Division in Europe, will be arriving soon. It is hoped that he will continue with the work which F/L Simkins has so excellently started.

The Section is admittedly in its infancy with little to show in the way of activities and progress to date. However, a firm base has been created on which to build an intensive programme in the fall term. With the continued help of the College authorities and the Vancouver Branch of the Institute, the future is full of promise.

*Graduation Ceremony*

Reported by R. J. McWilliams

The Vancouver Branch was honoured to receive an invitation to attend the Graduation Ceremony of the 1954 Class at Royal Roads on May 4, 1956, and was represented by the Secretary, Mr. R. J. McWilliams.

Nine C.A.I. Students were members of the Graduation Class and among the top-ranking Cadets presented with honours and awards were:

Prize of Honour—Cadet D. H. Allatt

Governor-General's Silver Medal—Cadet M. D. Thom

First Class Diploma—Cadet M. D. Thom

First Place Subject Prize—Senior, Cadet D. Fraser, Cadet M. D. Thom; Junior, Cadet G. G. Hopp.

Cadet G. G. Hopp is now a Senior at the College and graduates in one year's time.

Eight of the nine graduating Cadets pass on to R.M.C. Kingston for a further two years, to continue with their studies. Naval Cadet D. Fraser will be posted to England for a further three years of naval studies.

## NEWS

**Winnipeg**—Reported by N. D. Brewer

*March Meeting*

A technical session was held at 8.00 p.m. on March 27, 1956, in the Canadian Westinghouse Auditorium.

The speaker for the evening was Mr. E. F. Codd of Computing Devices of Canada, Ltd., on "Computing Devices and Data Processing". The speaker was introduced by the Vice-Chairman, Mr. J. J. Eden, in the absence of Mr. W. S. Haggett.

Mr. Eden first welcomed two guests, Mr. P. Hall of Vickers-Armstrong, England, and Mr. J. Hutton of Bristol Aero Engines Ltd. In introducing Mr. Codd, it was noted that he received his M.A. (Oxon) and spent considerable time with I.B.M. before joining C.D.C., where he is the Head of the Data Processing Department.

In his opening remarks, the speaker stressed that the present interest in computers was not merely an infatuation with machines, but was due to the growing need in modern day technology to obtain vast quantities of information rapidly and accurately and to process this information in the same manner, so as to be able to develop further refinements and obtain answers to technological problems and their solutions. He also pointed out their great use in aviation in such fields as aero elasticity, stability and control, model testing, structural analysis, etc. The accounting and administrative fields have also used computers in processing large amounts of statistical information.

The speaker then surveyed the historical development prior to the 20th century of calculating and computing machines and considered four outstanding events — Pascal's Desk Calculator, 1642, Babbage's Analytical Engine, 1833, Kelvin's Differential Analyzer, 1876, and Hollerith's Punch Card Sorter in 1890. Then the history of the analogue and digital types of machines, after the beginning of the 20th century, were discussed separately. The principles of operation of these machines were next surveyed, the digital type machine being discussed first.

The general purpose digital computer is characterized by its storage or "memory" in which it retains the data to be operated upon and the results of such an operation plus the instructions it is to follow. In addition, it can approximate to any degree of accuracy desired. Programming was discussed and the amount of work in establishing and checking the programme indicated.

Programming for the analogue machine was next considered and the necessity of establishing the correct analogue pointed out.

Mr. Codd also mentioned that accuracy is a limitation of an analogue machine since voltage levels are usually used to represent quantities.

Two basic approaches to a problem are possible. One involves direct translation of the problem into an analogous system; the other involves translation first into a mathematical model and then to the analogous system.

The speaker finally compared the two types of machines, digital and analogue, as to the type of problem, accuracy, amount of equipment, time of solution and cost.

Mr. Codd answered questions put to him by the members and in closing was thanked by Mr. W. M. Auld.

*Annual General Meeting*

The Annual General Meeting of the Winnipeg Branch was held on the evening of 22nd May, 1956, in the Albany Room of the Assiniboine Hotel with 88 members and guests present. A reception was held at 7 p.m. followed by dinner at 7.45.

After the dinner Mr. W. S. Haggett, the retiring Chairman, opened the meeting by welcoming those present and by introducing the head table and new and retiring Executive committees.

The new Executive consists of:

Chairman–J. J. Eden
Past Chairman–W. S. Haggett
Vice-Chairman–C. M. Hovey
Treasurer–N. D. Brewer
Secretary–C. Gross
Councillor–D. A. Newey
Councillor–H. W. Grant

Mr. Haggett then briefly reviewed some of the functions of the Institute such as the Council, Executive Committee, Admissions Committee, Publications Committee, Education and Training Committee, Programmes Committee, etc.

He then discussed more general matters pertaining to advancement of "the art, science, and engineering relating to aeronautics" in particular, the future and place of "this business of aviation in which we are all engaged", and the need for originality of thought and adequate training.

Mr. C. M. Hovey then read a letter from Mr. J. J. Eden, who was absent on business in Europe, in which Mr. Eden welcomed those present and reiterated his main objective, that of strengthening and building on the present foundation of the Winnipeg Branch.

Two films were shown. The first was "History of the Helicopter" by Shell Oil and the second "Air Power, 1956", by Bendix Aviation Corporation.

**Vancouver**–Reported by R. J. McWilliams

*Annual General Meeting*

The Annual General Meeting, held in the recently opened Admiral Hotel on April 20th, was attended by over 100 members and guests.

The Chairman opened the meeting by welcoming the guests, several of whom were from out of town and included C.A.I. members from the East.

Since the Annual Reports of the various Committees had been prepared in brochure form and distributed previously, it was possible to dispense with the reading of these reports and to pass on quickly to their adoption.

The Executive for the coming year were announced as follows:

Executive Committee
Chairman–Mr. I. A. Gray
Past Chairman–Mr. A. D. Cameron
Vice-Chairman–Mr. A. Stringer
Secretary-Treas.–Mr. R. J. McWilliams
Councillor–Mr. T. W. Siers
Councillor–Mr. A. T. Gilmour

The Chairman spoke of the many ways in which the Secretary had helped the Executive Committee and spoke highly of the efficient manner in which their various meetings had been arranged. It was therefore with some regret that he felt it incumbent upon him to speak of an omission in the agenda for this meeting; there appeared to be no mention of the presentation which had to be made. The Chairman, on behalf of all the members of the Executive Committee, then presented the Secretary with a desk pen set, in appreciation for his many personal kindnesses and service during the past year.

The Chairman spoke of the year which stretched before us and of his confidence in the ability of the new Executive to meet its problems. He wished them the very best of luck in all their dealings. The business section of the meeting was then adjourned.

Members and guests settled down to a very enjoyable evening of smorgasbord, dancing and talking. A very successful evening ended at 1.00 a.m.

**Toronto**–Reported by M. D. Willer

*April Meeting*

Mr. Fred Hanna, Technical Assistant to the President, Photographic Survey Corporation Ltd., gave an illustrated address on "Aerial Survey in the Development of Nature's Resources" at the final meeting of the winter series, held on 10th April last in the Mining Building, University of Toronto.

A distinguished guest was Sir Arnold Hall, formerly Director of the Royal Aircraft Establishment, Farnborough and presently technical consultant for the Hawker Siddeley Group, who, after an introduction by Mr. J. C. Floyd, Vice-President Engineering, Avro Aircraft Ltd., preceded the main address with an encouraging capsule account of the state of aviation in the United Kingdom.

Mr. Hanna began by defining some of the many forms of natural resources – animal, vegetable and mineral – which could be the subject of aerial survey. The increasing world population made it imperative that these resources should be speedily evaluated and developed.

Aerial survey, especially in terrain which offered physical or climatic obstacles to ground survey, provided a swift and economical means of assessing these resources with a high degree of accuracy and, by its very nature, gave a perspective which could be obtained in no other way. Photo interpretation – the technique of determining the maximum information from aerial photographs with a minimum of field examination – had made it possible to estimate timber volume in forest inventory to within 5 to 10%.

The problems involved in the growth of cities, such as transportation and communication, could be more quickly visualized and solved with the aid of aerial survey.

The field of aerial survey was highly competitive, the speaker said, and most operators were using elderly but reliable aircraft as their aerial platforms. The aircraft had to be as trouble-free as possible to enable the operator to fly long hours when climatic conditions were good for photography.

Mr. Hanna described some of the equipment used in photographic survey work, including the complex plotting mechanisms used for transferring photographic information to map sheets.

A radio aid to photogrammetry, which Mr. Hanna described, is the airborne profile recorder. Essentially a radar altimeter, the device makes a permanent record of the earth's profile below the flight path, automatically compensating for variations in the height of the aircraft above sea level.

Aerial survey, Mr. Hanna pointed out, was not limited to the surface of the globe. In geophysical survey the location of mineral deposits, many thousands of feet below the earth's surface, had been detected.

In the question period which followed, Mr. Hanna explained some of the advantages and disadvantages involved in the use of colour film for photographic survey and amplified some of the points mentioned in his main address.

*Annual General Meeting*

The final meeting of the Toronto Branch of the C.A.I. was held on Monday, April 30th, at the Elms Golf and

Country Club. This was a dinner meeting.

Following the dinner, the Chairman, W/C J. N. Brough, proposed a toast to the Queen and to the Patron of the C.A.I., the Duke of Edinburgh. He introduced the new Executive who had been elected as follows:

Executive Committee

Chairman–Mr. F. H. Keast
Past Chairman–W/C J. N. Brough
Vice-Chairman–Mr. J. W. Ames
Secretary–Mr. W. T. Heaslip
Treasurer–Mr. F. M. Hanna
Councillor–Mr. R. B. McIntyre
Councillor–Mr. S. L. Britton

Messrs. Floyd and Hunter's terms of office as Councillors will continue for another year.

The Chairman then requested reports from each of the Committee Chairmen. Mr. McIntyre submitted his report for the Programme Committee, covering briefly the various technical meetings held by the Branch. Mr. Crompton read his report on the work of the Meetings Committee during the year and thanked the members of the committee who had contributed their efforts to ensuring that the physical side of the meetings was looked after. He said that his report would include details on how future committees could best carry out their work.

Mr. Buller submitted a financial report and indicated that the Branch funds were in good shape.

Prof. Etkin, Adviser to the Student Section, reported the activities of this Section during the year. He recommended that the thesis competition, which was so successful, be carried on as an annual feature and, furthermore, that the Students be permitted to run one technical session each year, as in the past.

Prof. Loudon dealt briefly with the work of the Education and Training Committee and then presented a Certificate of Merit for the thesis competition to Mr. M. R. Subotincic.

In Dr. Glass' absence, the work of the Publications Committee was presented by W/C Brough. This report also requested that the Publications Committee work be extended for the following year.

W/C Brough summarized the reports of each of the Committees in his own report, which will be submitted to the Council.

W/C Brough then turned the meeting over to the incoming Chairman, Mr. F. H. Keast.

Mr. Keast thanked W/C Brough for the work which he had done in the past year and discussed briefly some of the work which he hoped the Branch would be carrying out during the forthcoming year. In concluding, Mr. Keast submitted the hope that the next year would be as successful as the 1955-56 season.

The meeting concluded with an interesting film on the National Air Show 1955, entitled "Air Power '56".

**Edmonton**–Reported by H. E. Davenport

*April Meeting*

The April meeting was held at the Auxiliary Officers' Mess, R.C.A.F. Edmonton, on the 24th April at 8.00 p.m. There were 25 members and guests present. The Branch Chairman, W/C J. G. Portlock, presided.

The feature item of the meeting was the presentation of a film showing various aspects of fire prevention in aircraft accidents. The film was very well produced and illustrated the main causes of crash fires and suggested design improvements likely to reduce this type of hazard. A lively discussion followed the showing of the film, during which the members drew on their own experiences regarding the subject. It was generally agreed by the meeting that much development could still be done in this important aspect of aircraft safety.

After the discussion ended, matters of business were discussed, particularly the need for increased membership in the Branch. The Membership Committee Chairman, Mr. Young, reported on the activities of his Committee and stated that there were many applications already in the initial submission stage.

The Chairman announced that plans for the May and June meetings were almost complete and interesting programmes were promised.

After the business meeting, refreshments were served and after a very pleasant social hour or so the meeting adjourned.

*May Meeting*

The May meeting of the C.A.I. Edmonton Branch was held in the Auxiliary Officers' Mess, R.C.A.F., on Tuesday, May 15, 1956. G/C J. R. Frizzle, Vice-Chairman, presided. Thirty-two members and guests were present.

Reports were made by S/L J. A. G. Diack, Chairman of the Programme Committee, and Mr. C. C. Young, Chairman of the Membership Committee. Mr. Young requested that all Branch members participate in recruiting new members.

Nominations for the next Executive Committee are currently being sought and the election of officers is scheduled for the next meeting on June 12th.

The Chairman read a report from W/C J. G. Portlock, who was absent, dealing with the recent Annual General Meeting of the Institute in Montreal. This report was comprehensive and gave the members a clear picture of the main business conducted at the Annual Meeting.

G/C Frizzle introduced the speaker, F/O K. Weinstein, Project Engineer on the Winterization of the Blackburn Beverley, who chose as his subject "Low Temperature Trials of the Blackburn Beverley". The talk was both interesting and instructive and showed that the problem of cold weather operation had been approached in a scientific manner with a fair measure of success.

**Ottawa**–Reported by Dr. A. Jaworski

*Annual General Meeting*

The season's final meeting was held on May 9th, as usual at the Beaver Barracks. About 60 members and guests were present.

The Chairman of the Branch, Mr. J. L. Orr, in his opening remarks, pointed out that the annual business session would be held after the paper was presented by the speaker.

S/L S. V. McKeague was called by the Chairman to introduce formally the speaker of the evening, W/C J. G. Wright, Directorate of Instruments and Electrical Engineering, R.C.A.F. Headquarters. S/L McKeague indicated the distinguished war record of the speaker and the fact that actually no introduction was required as the speaker is a very well-known expert in air navigation and, therefore, fully qualified to speak on the topic "Principles of Automatic Navigation".

The speaker briefly characterized the three basic references which are used in air navigation, space, air and ground, and the whole galaxy of navigational instruments. He pointed out that any gyro mechanism, which records the reference to space, requires a monitoring device in long distance flying to take account of the curvature of the earth, which, of course, cannot be shown by the gyro itself. The speaker was using the term "monitors" in a very broad sense[a] to encompass all corrective devices which are needed for long distance flying. As was brought out during the discussion period, it is very difficult to define the flying distance for which the use of corrective devices becomes essential; usually an ordinary rectangular grid is sufficient for practical purposes when flying is restricted to an area of 300 by 300 miles or to a journey between two points situated within 1,000 miles of each

[a]It may be added that recently Sperry's senior engineers have defined a "monitor" as an instrument which provides an indication that the primary information is in error, and nothing more. On the other hand, a "stand-by instrument", in addition to an error indication, provides the means of achieving adequate flight control. AERONAUTICAL ENGINEERING REVIEW, MAY, 1956, p. 64.

other; with some partial correction, the direct journey could even be extended to 4,000 miles. It is important that the first input of information be approximately correct so that by applying corrective devices in successive stages the indication may be made to converge relatively quickly into a narrow band of error.

Referring to the practical advantages of over-printing polar coordinates, the R-Theta grid, over standard 1:1,000,000 scale maps, the speaker pointed out that it is much easier to locate a position on a polar grid by referring to, for example, 130°/146 miles than to trace it down to 42° 36′ N, 76° 18′ W. In this connection the speaker exhibited several instruments including the R-Theta computer. By means of a diagram, the speaker illustrated the essential sensing and monitoring features of a navigational system and emphasized the need for as much automaticity as possible to eliminate errors of human observation, particularly at present-day high aircraft speeds.

The discussion was chiefly concerned with the possibility of further improvements which might be expected in automatic navigational computing devices.

The Chairman then introduced the business meeting and called on the Chairmen of the various Committees to submit their annual reports.

Firstly, Mr. C. D. Long, Chairman of the Programme Committee, briefly summarized the lectures presented monthly during the past season. Nine papers covering a wide field of interest had been presented and the average attendance had been slightly over 25% of the membership of the Branch.

For the Membership Committee, in the absence of the Chairman, G/C C. W. Crossland, the report was presented by Mr. J. C. Finlayson, a member of the Committee. In addition to 22 applications at present in the hands of the Admissions Committee, Mr. Finlayson reported that 61 new members had been enrolled during the last year, bringing the total membership of the Branch to 227.

The Secretary, in his report, pointed out that the yearly turn-over ratio was quite high, about 45% of the total membership; he made a special plea to members to keep the new Secretary informed of their telephone numbers, pointing out that due to the recent changes in the Ottawa area the present Branch records, in respect to telephone numbers, were out of date.

Finally, the Treasurer, Mr. R. B. Ferris, reported that the annual revenue amounted to $354.00 against expenses of $306.51, the balance on March 31, including the carry-over from the previous year, amounting to $104.73. He explained that some difficulty arose from the fact that whereas the revenue of the Branch is received from Headquarters in October and January, the Branch's expenses begin in September and continue to May.

The Chairman then asked Mr. H. C. Luttman, Secretary of the Institute, to say a few words on the subject of membership grading on which he was continually receiving enquiries. Mr. Luttman prefaced his remarks by saying that he was expressing only his personal views and had no authority to express the official views of the Council. By and large, the C.A.I.'s scale of grades is more closely related to I.A.S. practice than to R.Ae.S. practice and lays relatively little stress on academic qualifications as such. The minimum years of experience required by the By-laws for each grade are always strictly observed by the Council, but the Council relies fairly heavily on the opinions expressed by the references in assessing the applicant's standing. In this connection, Mr. Luttman said that, during the organizational period of the Institute, references were not followed up and for this reason some mis-grading may have taken place at that time. Finally, he emphasized that upgrading is not automatic and that anyone who considers that he meets the requirements for a higher grade should apply, using the special form which may be obtained at any time from the Secretary's office.

The reports were approved by the members and Mr. Orr handed over the meeting to Mr. M. S. Kuhring, the Chairman for 1956-57.

Mr. Kuhring complimented the outgoing Executive for their work and adjourned the meeting at 11.30 p.m.

**MEMBERSHIP OF THE C.A.I.**

as at the Meeting of the Council on the 2nd May, 1956.

| | |
|---|---|
| **Technical** | **1,483** |
| **Associate** | **59** |
| **Total** | **1,542** |

The Technical grades comprise the following:

| | |
|---|---|
| Honorary Fellows | 11 |
| Fellows | 24 |
| Associate Fellows | 180 |
| Members | 735 |
| Technical Members | 400 |
| Technicians | 29 |
| Students | 104 |

# MEMBERS

## ADMISSIONS

At a meeting of the Council, held on the 2nd May, 1956, the following were admitted to the grades of membership shown.

### *Associate Fellow*

**W. M. Auld,** Assistant General Manager, Bristol Aircraft (Western) Limited, P.O. Box 874, Winnipeg, Man.

**R. Bannock,** Director, DeHavilland Aircraft of Canada, Ltd., Postal Station L, Toronto, Ont.

**S/L R. G. Christie,** (on transfer from Member)

**F. C. Phillips,** Chief, Aerodynamics and Preliminary Design, Canadair Ltd.: *275 Laird Blvd., Town of Mt. Royal, Montreal, P.Q.*

### *Member*

**D. L. Bailey,** Technical Officer, National Research Council: *508 Blair St., Ottawa, Ont.*

**W. H. S. Bird,** Special Assignments Engineer, Trans-Canada Air Lines, Engineering Dept., Montreal Airport, Dorval, P.Q.

**F/S G. L. Capuano,** Aircraft Maintenance Superintendent, R.C.A.F., M.P.O. 503, Grande Centre, Alta.

**G. D. Clapp,** Stress and Weights Office, DeHavilland Aircraft of Canada, Ltd.: *13 Barton Ave., Toronto, Ont.*

**S/L J. J. Collins,** Chief Project Engineer, Air Armament Evaluation Detachment, M.P.O., 503, Grande Centre, Alta.

**R. Hayward** (on transfer from Technical Member)

**A. D. Marshall,** Technical Assistant, Canadair Ltd.: *Valcartier Station, St. Catherines Road, P.Q.*

**J. McCormick,** Production Superintendent, Bristol Aircraft (Western) Ltd., P.O. Box 874, Winnipeg, Man.

**M. E. McMillan,** Supervisor, Accessory Shop, Standard Aero Engine Ltd., Box 764, Winnipeg, Man.

**E. F. O'Mara,** President, Comar Limited, 645 Montee de Liesse, Box 222, Station O, Montreal 9, P.Q.

**K. T. Owen,** Staff Writer, Flight: *8 Raleigh House, Albion Ave., London, S.W. 8, England.*

**L. G. Randlesome,** Maintenance Assistant, Trans-Canada Air Lines: *308 Regal Ave. E., St. Vital, Winnipeg, Man.*

**J. M. Ross,** Manager, Central Aviation Ltd., Wetaskiwin, Alta.

**Maj. J. L. Sloan,** Technical Staff Officer, Directorate of Vehicle Development, Army Headquarters: *560 Wavell Ave., Ottawa, Ont.*

**P. S. Thomas,** Overhaul Engineer, Rolls-Royce of Canada, Ltd.: *Ste. 5, 587 Broadway Ave., Winnipeg 1, Man.*

**J. A. Tremills,** Special Weapons, Canadair Ltd.: *1190 St. Germain Blvd., St. Laurent, Montreal 9, P.Q.*

**A. H. Walker,** Aircraft Inspector, Dept. of Transport: *206 Oakdean Blvd., St. James, Man.*

**I. L. White,** Hangar Superintendent, Northwest Industries Ltd.: *11403 - 122 St., Edmonton, Alta.*

**W. E. White,** Director, Instruments and Electronics, Canadian Arsenals Ltd.: *260 Metcalfe St., Apt. 505, Ottawa 4, Ont.*

### *Technical Member*

**F/O P. Bussieres,** Project Engineer, C.E.P.E., R.C.A.F. Stn., Rockcliffe: *Officers' Mess, R.C.A.F. Station, Rockcliffe, Ont.*

**R. W. Byron,** Service Technician, Avro Aircraft Ltd.: *c/o Sergeants' Mess, M.P.O. 503, Grande Centre, Alta.*

**J. G. Davidson,** Administrative Assistant to Chief Engineer, Bristol Aircraft (Western) Ltd.: *90 Rowand Ave., St. James, Winnipeg 12, Man.*

**W. Duncan,** Aircraft Inspector, Northwest Industries Ltd.: *11901 - 122 St., Edmonton, Alta.*

**C. E. Gates,** Technician, Canadair Ltd., Engineering Department, Box 6087, Montreal, P.Q.

**B. Larmour,** Analysis Officer, R.C.A.F., A.M.C.H.Q., Rockcliffe, Ottawa, Ont.

**J. R. MacLeod** (on transfer from Student)

**J. McAllister,** Instrument Inspector, Avro Aircraft Ltd.: *c/o Sergeants' Mess, M.P.O. 503, Grande Centre, Alta.*

**R. Melsom,** Service Engineer, Canadair Ltd.: *11780 Reed Blvd., Ville St. Laurent, Montreal, P.Q.*

**A. Petroff,** Aircraft Technician, Avro Aircraft Ltd.: *c/o Sergeants' Mess, M.P.O. 503, Grande Centre, Alta.*

**P. P. Sowsun,** Senior Draftsman, Trans-Canada Air Lines: *500 Sherburn St., Winnipeg, Man.*

**R. H. P. Timms,** Design Draftsman, Northwest Industries Ltd.: *12948 - 118 Ave., Edmonton, Alta.*

**Cpl. J. P. Vallee,** N.C.O. in charge of Instrument Section, R.C.A.F., Cold Lake: *M.P.O. 503, Grande Centre, Alta.*

### *Student*

**P. Bilodeau,** Laval University: *4 Laporte St., Quebec City, P.Q.*

**Cadet L. C. Cook,** Canadian Services College, Royal Roads, Victoria, B.C.

**M. H. Cooper,** University of Manitoba: *615 Ingersoll St., Winnipeg, Man.*

**M. J. Crocker,** Sir George Williams College: *5694 Queen Mary Rd., Montreal, P.Q.*

**Cadet A. E. Cummings,** Canadian Services College, Royal Roads, Victoria, B.C.

**Cadet P. J. Dawson,** Canadian Services College, Royal Roads, Victoria, B.C.

**F. H. Devereux,** Provincial Institute of Technology and Art: *535 River Drive, Bowness, Alta.*

**E. D. Feldman,** Sir George Williams College: *601 Clarke Ave., Westmount 6, P.Q.*

**G. W. Grover,** Provincial Institute of Technology and Art: *1421 - 9th St., N.W., Calgary, Alta.*

**Cadet G. G. Hopp,** Canadian Services College, Royal Roads, Victoria, B.C.

**C. G. Luckman,** University of Manitoba: *Ste. 7A Amboyd Apts., 311 St. Mary's Rd., Norwood, Man.*

**Cadet A. O. Manson,** Canadian Services College, Royal Roads, Victoria, B.C.

**Cadet R. D. McCracken,** Canadian Services College, Royal Roads, Victoria, B.C.

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# SUSTAINING MEMBERS

**NEW SUSTAINING MEMBER**

THE following Company has joined the Institute as a Sustaining Member:

**S. Smith & Sons (Canada) Limited**

**NEWS**

**Orenda Engines Ltd.** announces a $7.7 million expansion programme which, as explained by Mr. W. R. McLachlan, Vice-President and General Manager, will enable the Company to carry out approximately 90% of their own testing. The extensive programme includes,

At Malton

Six new soundproof development test cells, with provisions for extending the number to eight,

A soundproof high altitude test facility, which will permit engine testing in the rarified cold atmospheric conditions encountered at high altitudes – without the necessity of ever leaving the ground,

A soundproof aerodynamic test facility, which will incorporate a wind tunnel for testing airfoil designs for jet engine blades, and

A soundproof combustion facility, for testing performance and efficiency of engine and afterburner combustion.

At Nobel

A test facility for developing mechanical design features of afterburners,

A test cell for investigation of internally cooled turbine blade design under conditions similar to those in the engine, and

A two-storey office building and single-storey storage building, both extensions to present capacity.

In addition, the following major items will be built at Malton: a road linking the Company's production plant with its engineering and laboratory buildings; a two-million-gallon water reservoir; a 350,000-gallon fuel tank increasing present storage capacity to 650,000 gallons; an electrical step-down station to provide 25,000 horsepower.

Malton construction, totalling 160,000 sq ft of floor space, will occupy 17½ acres of land. Nobel construction will add approximately 20,000 sq ft of floor space.

All the Nobel programme and part of the Malton work will be completed by the end of this year. The electrical step-down station will go into operation around September, 1957, the exact date being controlled by the completion date of Ontario Hydro's new Richview transformer station.

**A/C K. V. Hodson opening the PSC Applied Research Environmental Test Laboratory. The equipment shown is an electromagnetic shaker for vibration testing. In the group, (l to r), are Dr. O. E. Braaten, head of the laboratory, Mr. D. N. Kendall, Vice-President, Hunting Associates Ltd., Mr. J. M. Bridgman, general manager, PSC Applied Research Ltd., A/C Hodson, and Mr. W. G. Wilson, laboratory supervisor.**

**PSC Applied Research Ltd.** celebrated the 10th anniversary of the Hunting companies in Canada with the opening of its new Environmental Test Laboratories on the 16th May. The opening ceremony was performed by Air Commodore K. V. Hodson. The new laboratories contain some interesting equipment which is briefly described below.

The vibration testing equipment comprises two low frequency vibrators and an electromagnetic shaker for high frequency testing. The low frequency vibrators, one for horizontal and the other for vertical testing, each have a capacity of 1,000 g lb, a maximum displacement of 0.125″ in the horizontal or vertical plane and a frequency range of 10 to 60 cps; maximum load is 150 lb. The electromagnetic shaker has a capacity of 600 g lb, a frequency range of 5 to 2,000 cps and maximum displacement of 1″. There is automatic cycling through any portion of the frequency or displacement ranges within the limits of the machine, in either the horizontal or vertical plane.

A 50 lb capacity shock tester is also provided with accelerations up to 220 g and a maximum shock duration of 0.012 seconds.

For radio interference testing, the laboratory is equipped with a screen room and ancillary equipment giving a frequency range of 0.15 to 1,000 mcs.

The laboratory also incorporates an icing wind tunnel having a 12″ × 12″ working section and, at present, a 24 hp motor giving a maximum indicated air speed in excess of 400 fps. The tunnel has a maximum design water content of 2.5 grams/cubic meter at maximum speed. The design median droplet size control is from 15 microns to greater than 1,000 microns at ½ maximum water

content and 30 microns to greater than 1,000 microns at maximum water content.

The temperature humidity and temperature altitude equipment comprises two chambers each of 27 cu ft capacity. The temperature humidity chamber has a temperature range of −25°F to +300°F and a humidity range of 20 to 98% with recorded automatic control and cycling. The temperature altitude chamber has a temperature range of −120°F to +300°F and a pressure range from sea level to 100,000 ft with automatic control and recording.

In addition, there is a small altitude chamber of 9 cu ft capacity, manually controlled, and having a pressure range from sea level to 80,000 ft; a manually set, thermostatically controlled, temperature chamber of 12 cu ft capacity and a range of −90°F to +200°F; and a high temperature oven with a 3 cu ft capacity, thermostatically controlled up to 400°F. Finally, a salt spray and humidity testing tank of 48″ × 36″ × 26″ is available.

Sand and dust, explosion proofing and fungus resistance testing equipment will be added to the laboratory in the near future.

**Field Aviation Company, Ltd.** has entered into an agreement with Timmins Aviation Ltd. of Montreal, whereby Field will be authorized to sell in Ontario the Royal Gull, for which Timmins are the Canadian distributor, while Timmins has been appointed the dealer in Quebec and the Maritimes for the Beech executive aircraft controlled by Field.

The Royal Gull (two 270 hp Lycoming engines) is an amphibian, designed and built by the Piaggio company and assembled in North America by the Royal Aircraft Corporation of Milwaukee. It is a five-seater of normal gross weight of 6,000 lb, maximum speed of 164 mph and range of about 1,000 miles. It promises to be a valuable aircraft for Canadian operations.

**Decca Navigator (Canada) Ltd.** announces that, on the suggestion of I.C.A.O. and in cooperation with the United Kingdom, the Department of Transport has decided to carry out evaluation trials of a new trans-Atlantic air navigation system. The system will be installed this year and will be the first attempt to give complete area coverage to the North Atlantic air routes.

Canada is vitally interested in the possibilities of any system which can supply complete air navigation coverage of the North Atlantic route, as its airport at Gander, Newfoundland, provides the first landfall for westbound trans-Atlantic air traffic and the jumping off place for eastbound planes. There are at present several systems which offer this possibility.

During the busy season out of Gander airport, there are today more than 100 aircraft in the air in the North Atlantic area for prolonged periods of the 24 hour day. As a result, these designated airlanes are being filled to near capacity and with the introduction of jet, turbo jet, and other aircraft capable of operating at great speeds and at high altitudes, the enforcement of adequate safety standards can result in flights being delayed or cancelled.

Temporary installation of two DECTRA stations in Canada will take place to facilitate operation trials of this new long distance radio aid to navigation developed by the Decca Navigator Company Ltd., England. Construction and operation will be under the direct control of Decca Navigator (Canada) Ltd., Toronto. These stations will be located at Comfort Bay and Thorburn Lake near Gander, Newfoundland. They are intended to operate in conjunction with two similar stations at Prestwick, Scotland, and it is expected that a thorough evaluation test will be possible in 1957. Evaluation of the DECTRA System will be carried out by aircraft operating on the North Atlantic belonging to the Ministry of Supply of the United Kingdom and by other British and Canadian aircraft.

I.C.A.O. has been trying for several years to establish a standard long distance aid to navigation and has recommended that those states in a position to do so continue development and evaluation of long distance radio navigation aids in order to provide sufficient information to establish a standard system for world-wide use. DECTRA is one of several systems which may be considered by I.C.A.O. for world-wide adoption and the information gained from these trials would be valuable in comparing the merits of the various systems.

The DECTRA System employs two stations spaced approximately 80 miles apart at each terminal. It is claimed that transmissions from the two pairs of stations will produce lanes approximately parallel, by means of which aircraft flying on similar tracks will be able to fly with small but safe lateral separation. A track provides the aircraft with a fixed path, while a range pattern registers the distance the aircraft is from its destination and point of departure.

Under existing systems, the aircraft crew is called upon to undertake time-consuming chart plotting. Under the system to be tested, a standard flight log will be mounted in the cockpit of aircraft. In accordance with tracking and ranging information, a moving pen will indicate on the chart the position of the aircraft, enabling the pilot to read his distances from Prestwick and Gander and to see at a glance any deviation from the allocated track.

**The Jet Ignition Company** has given us some interesting particulars of the Jet Flame Igniter which they handle. The Jet Flame Igniter is intended to replace the conventional spark plugs on piston engines; in fact it is very similar to a conventional spark plug except that its insulator and electrodes are surrounded by an annular chamber, closed by a shield which carries the ground electrode at its centre. The chamber is connected to the combustion chamber of the engine by three tangentially disposed holes; moreover the ground electrode is drilled axially to provide a fourth passage and, in effect, an annular spark gap.

In the open type of spark plug, the control of temperature, carbon and lead deposit is effected by designing the plug for a pre-determined rate of heat dissipation; in the Jet Flame Igniter, however, these factors are controlled by the design of the shield, the annular chamber and the size and inclination of the tangential holes.

The holes are so located that they reduce to a minimum the radiant heat transmitted to the insulator and electrodes, thereby reducing erosion and conditions conducive to pre-ignition and erratic running. The gases entering the tangentially disposed holes during compression form a vortex around the annular chamber, which not only enhances carburation but by its scouring action keeps the electrodes and insulator free of deposits. The constant reversals of the high speed flow of gases through the tangential holes in the shield and the axial hole in the ground electrode keep these passages and the spark gap itself free from fouling.

On ignition of the charge in the annular chamber, flames are discharged through the tangentially disposed passages into the combustion chamber of the engine and it is claimed that this divergent spray of jet flame results in more complete combustion of the main charge than can be achieved by direct ignition by a spark.

# INSTRUCTIONS TO CONTRIBUTORS

The Canadian Aeronautical Institute invites the submission of papers, articles and technical notes for publication in the Canadian Aeronautical Journal. Following the practice of other societies, the Institute does not pay for contributions.

Authors should prepare their material in accordance with the following directions:

**Manuscripts.** Manuscripts should be
(a) Typewritten, double-spaced,
(b) On one side of 8½ x 11 white paper,
(c) With wide margins, approximately 1½", and
(d) With pages numbered consecutively.

Manuscripts must be in final form; the addition of material after acceptance by the Institute cannot be permitted.

**Titles.** The following form should invariably be adopted:—
(a) Titles should be brief;
(b) The name and initials of the author should be written as he prefers; (Rank or title preceding the name e.g. Wing Commander or Dr., should be included but abbreviations of degrees etc., after the name, should be omitted.);
(c) The name of the organization with which the author is associated should be shown under his name; and
(d) The author's position in the organization, referred to in (c) above, should be shown as a footnote to the first page.

**Summaries.** Each paper should be preceded by a summary
(a) Of 100 to 300 words, (10 to 35 lines, double-spaced),
(b) In non-specialist language, so far as possible,
(c) Stating the main conclusions of the paper.

**Sub-Headings and Paragraph Numbering.** Sub-headings should be inserted by the author at frequent intervals. Paragraphs should not be numbered.

**References.** References referred to by the author should be treated thus:—
(a) References should be numbered consecutively throughout the paper;
(b) An allusion to a reference should be indicated by a bracketed numeral e.g. "It has been shown by Dr. T. T. James (7) . . . ";
(c) Direct citation of a reference in the text should be written in full, e.g. "As shown in Reference (7) . . . "; and
(d) References should be grouped together in numerical order at the end of the paper, each showing
first, the numerical designation, e.g. "(7)".
second, the author's name, e.g. "James, T. T."
third, the title of his work, e.g. "Aerodynamics and Ballistics"
fourth, the title, volume, issue no, and date identifying the publication in which it appeared, e.g. "R.B.S. Journal, Vol. 7, No. 77, July 1907".

Thus "(7) James, T. T.,—Aerodynamics and Ballistics, R.B.S. Journal, Vol. 7, No. 77, July 1907."

**Footnotes.** Comments on or amplification of the text should be given in footnotes, appearing at the bottom of the appropriate pages.
(a) Footnotes should be designated alphabetically and consecutively throughout the paper; and
(b) A reference to a footnote in the text should be indicated by a bracketed letter, e.g. "omitting consideration of the third power (c) . . . "

**Figures, Tables and Equations.** Reference in the text to
(a) Figures and Tables should be given in full, e.g. "Figure 7", but
(b) Equations should be abbreviated to Eq., e.g., "Eq.(7)" or "Eqs.(5) and (6)".

**Drawings.** Drawings should be
(a) Individually identified by Figure or Table number,
(b) Not larger than 12" x 16",
(c) In black ink on white paper or tracing cloth, and
(d) Capable of being reduced to 3½" wide without loss of legibility of lettering or other detail.

**Photographs.** Photographs should be
(a) Black and white, glossy prints, and
(b) Individually identified by Figure number, written on a separate piece of paper affixed to the back: writing on the back of the photographs should be avoided.

**Captions.** Each Figure and Table should be identified by a caption, in addition to its number, e.g., "Figure 12 Theoretical lift distribution".
(a) The caption of a Table should be shown at the top of the Table;
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(c) A complete list of Figure and Table captions should be given on a separate sheet of the manuscript.

**Mathematical work.** Only the simplest mathematical expressions should be typewritten; others should be carefully written in ink. Mathematical work should be
(a) Uncrowded—plenty of space should be provided to accommodate directions to the printer—,
(b) Repeated on a separate sheet of the manuscript, again uncrowded and with plenty of space around each expression,
(c) Clearly written to distinguish between like symbols. e.g. between zero and the letter 'o', and between Greek and English letters of similar form, and
(d) Accompanied by a manuscript "index" of the Greek letters used in the paper, identifying each letter by a name, e.g. "α—alpha".

In addition the following practices should be adopted:
(a) Simple fractions appearing in the text should be shown with a solidus, e.g. A/(B+C) rather than as

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(b) Complicated expressions should be identified by some convenient symbol, if necessary to avoid repetition of the whole expression; and
(c) Complicated subscripts and exponents, and dots and bars over letters or symbols should be avoided.

**Symbols and Abbreviations.** Consistency is important;
(a) The symbols recommended in the American Standards Association "Letter Symbols for Aeronautical Sciences" ASA Y10-7—1954 should be used wherever practicable; and
(b) Abbreviations of units should be shown in lower case without periods, e.g. lb, mph, bhp, etc.

**Mailing.** Papers should be mailed to The Secretary, Canadian Aeronautical Institute, 607 Commonwealth Building, 77 Metcalfe St., Ottawa 4, Canada.
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(b) Manuscripts should be mailed flat.

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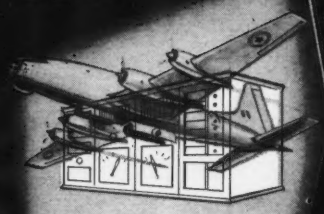

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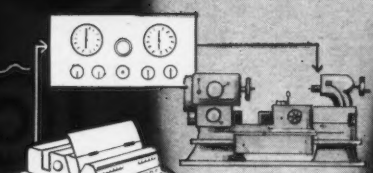

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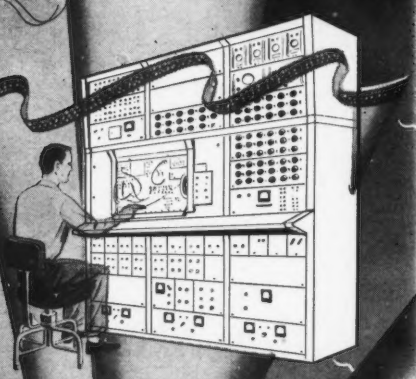

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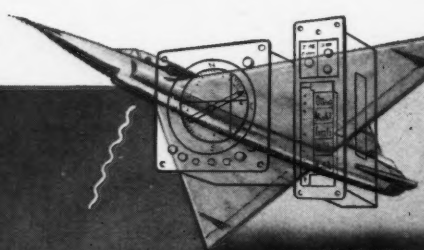

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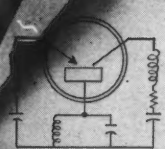

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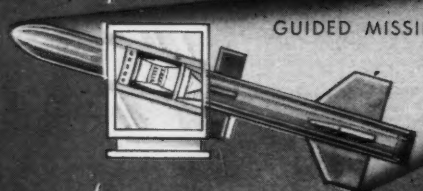

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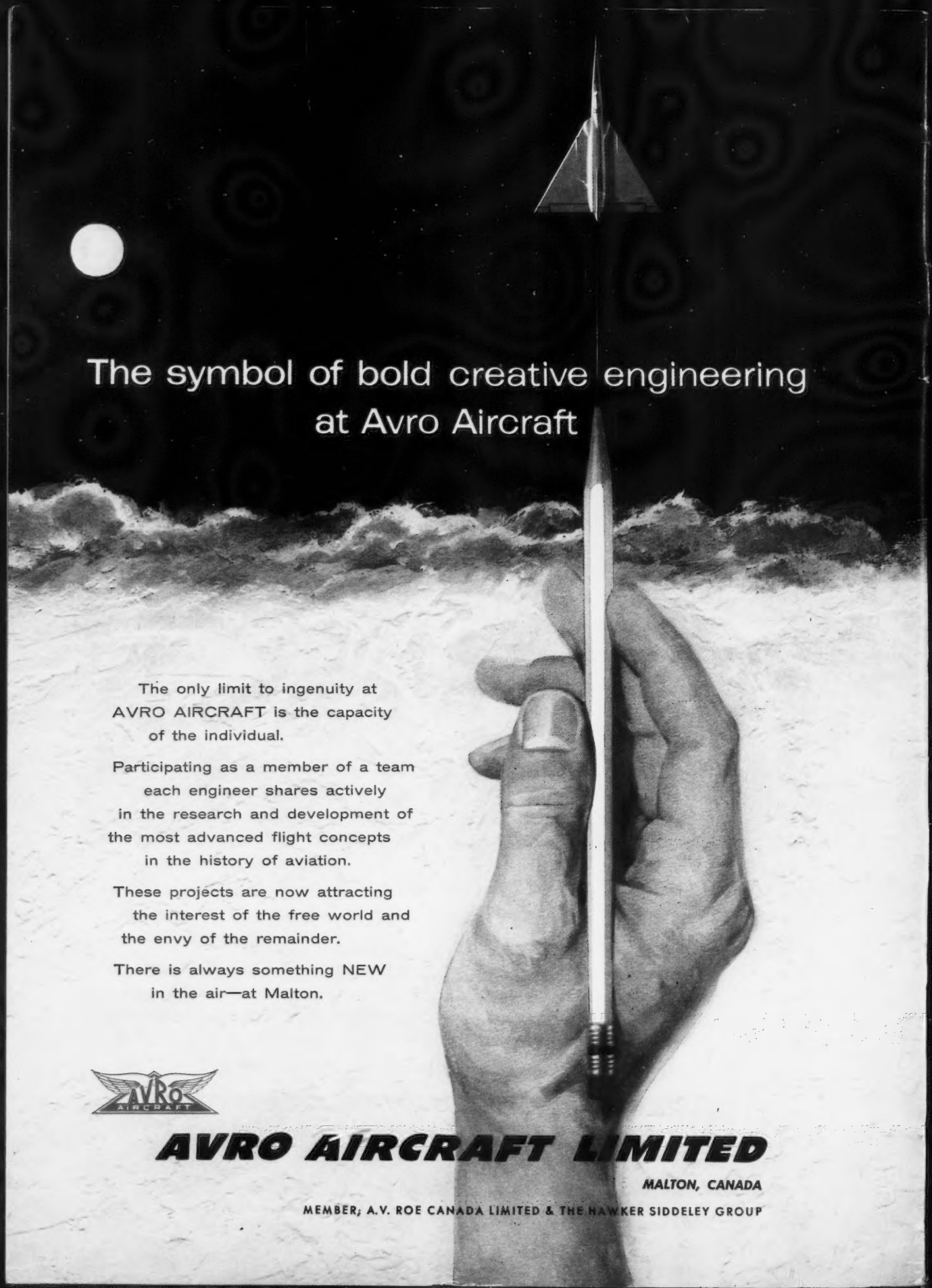
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